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Alternative futures of exports, farm size and government programs for American agriculture

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CHAPTER I. INTRODUCTION

American agriculture has undergone many persistant and dramatic changes throughout this century. These changes have transformed agriculture from a labor intensive to a highly capitalized industry. At the same time that the number of people on farms has declined the average farming operation has increased sharply in size. As the farm labor force declined, communities which had developed to serve it were greatly affected. In many cases, the size and viability of these rural communities has been severely diminished.

This chapter of the manuscript is devoted to a discussion of some of the changes mentioned above, their affects on rural communities and government actions to relieve the resulting distress. These subjects, presented in the first five sections of the chapter, have this order of presentation: changes in agricultural productivity, changes in the demand for agricultural products, major government programs to provide income relief for agriculture, changes in average farm size and affects on the rural community. This presentation is followed by a statement of the objectives of the quantitative study with which the rest of the manuscript deals. The quantitative study estimates future outcomes for a major segment of the agricultural industry under alternative assumptions for certain key parameters. This chapter, dealing with past trends, provides a basic understanding for judging the validity of the estimates relating to the future of agriculture.

Changes in Agricultural Productivity

A major factor contributing to the change in U.S. agriculture during the last three decades was the development and adoption of new technology. Henderson and Quandt define the individual entrepreneur's technology as "...all the technical information about the combination of inputs necessary for the production of his output" (18, p. 54). This definition implies that individual entrepreneurs are able to choose among different methods of combining available inputs to produce output. Therefore, at a point in time, processes which are not known to individual producers are not part of their relevant technology.

The Henderson and Quandt definition refers to the technology existing at any point in time. But the technology available to the individual U.S. farmer does not remain static. Instead, his technology increases as his knowledge of new processes grows and as even newer processes are developed. This ongoing process of discovery and dissemination of new knowledge has contributed greatly to the technological progress which has occurred, and is continuing, to occur in American agriculture.

Cochran as cited by Hathaway (9) defines the process of adoption of new technology as, "An increase in output per unit of input resulting from a new organization, or configuration, of inputs where a new and more productive production function is involved" (9, p. 46). According to this definition, technological progress includes any changes in the organization of inputs (i.e., because of new information or farm consolidation), as well as changes in the physical production function. Ferguson concurs when he defines technological progress as, "...any change of the production function that either permits the same level of output to be produced with less input or enables the former level of inputs to produce a greater output" (7, p. 421).

In general a technological innovation may be factor-saving, factor-using or output increasing (10, p. 803). Also factor-saving or factor-using innovations can be output-increasing as well. Each of these types of innovations have affected the nations farming industry. Heady (10, p. 803) provides the following illustrations for agriculture; hybrid seed--output-increasing, improved tractors and machines--factor-saving, improved fertilizer--both factor-using and output-increasing, and artifical insemination--factor-saving.

The data in Table 1 partially indicate the magnitude of the technological change which has taken place in American agriculture. Between 1939 and 1970, farm output increased by

75 percent even though government programs to reduce farm production were in effect throughout much of this period. And this sharp jump in production was attained with only a slight increase in the total quantity of inputs used in farming. For the time period shown in Table 1 input usage peaked during the Korean conflict of 1951 and 1952.

Although the quantity of farm output produced and farm inputs used both may be affected by technological change, a more proper indicator of technological progress is given by the third category presented in Table 1, farm output per unit of input. In 1939, farm output per unit of input was only 59 percent of its 1970 level. Although the value of this indicator climbed rapidly throughout the 1939-70 period, the bulk of its increase had occurred by 1960, with more moderate increases occurring in the last decade.

The data of Table 1 indicate the aggregate effects of technological change in agriculture, however, they only partially describe the impacts on the entire farming community. While the total usage of inputs in farming remained nearly constant in this time period, the use of some inputs increased while the use of others decreased. The effect of any particular innovation on the usage of a certain input is determined by the manner in which the innovation alters that inputs competitive position in the production process.

Table 1. Indices of farm output, farm inputs and output per unit of input[a]

Year	Farm output	Total inputs	Output/ unit input
1939	58	97	59
1940	60	98	61
1941	62	98	63
1942	69	101	69
1943	68	102	67
1944	70	103	68
1945	69	100	69
1946	71	99	72
1947	69	99	70
1948	75	100	75
1949	74	102	73
1950	73	101	73
1951	75	104	73
1952	78	104	76
1953	79	103	77
1954	79	102	78
1955	82	102	80
1956	82	100	82
1957	80	97	83
1958	86	97	89
1959	88	98	90
1960	90	97	93
1961	90	96	94
1962	91	96	95
1963	95	97	98
1964	94	98	96
1965	97	98	99
1966	96	99	97
1967	100	100	100
1968	102	101	101
1969	103	102	101
1970	102	102	100

[a]Source: (42).

Since the adoption of new innovations has altered the competitive position of certain inputs, the nature of technological change, and the resulting changes in the requirements for the individual resources comprising farm inputs, are also of great importance. In Table 2 total input usage in agriculture, as well as the usage of three major categories of inputs, are presented. This data illustrate the change in the relative usage of different farm inputs in the last three decades. Although technological progress has been a major factor contributing to these changes, changes in the relative prices of these inputs also have affected their usage.

Although total input use remained stable throughout the last three decades, the data in Table 2 show that the usage of both mechanical power and machinery and fertilizer and lime has jumped dramatically. The usage of mechanical power and machinery increased by over 150 percent from 1939 to 1970 as the conversion from animal power to tractors and trucks was completed and as the potential of rural electrification was realized by farmers. During this same period, the usage of fertilizer and lime grew by more than 840 percent.

In contrast to the tremendous increase in the use of these two inputs, farm labor usage plummeted during this same period. In 1970 farm labor usage was only one-third of what it had been immediately before World War II. This sharp decrease in farm employment not only affects the farm producer,

Table 2. Indices of input usage in American agriculture[a]

Year	Total inputs	Farm labor	Mechanical power and machinery	Fertilizer and lime
1939	97	270	40	12
1940	98	269	42	14
1941	98	265	44	15
1942	101	271	50	17
1943	102	267	53	19
1944	103	265	55	23
1945	100	249	56	23
1946	99	239	55	24
1947	99	226	60	28
1948	100	220	68	29
1949	102	212	75	31
1950	101	199	79	32
1951	104	200	84	36
1952	104	191	88	39
1953	103	184	90	42
1954	102	176	90	43
1955	102	170	91	45
1956	100	160	91	44
1957	97	149	90	46
1958	97	143	91	48
1959	98	139	92	54
1960	97	134	91	54
1961	96	129	90	58
1962	96	123	91	62
1963	97	120	92	70
1964	98	115	93	76
1965	98	109	96	80
1966	99	101	100	90
1967	100	101	100	100
1968	101	96	102	107
1969	102	94	103	110
1970	102	89	102	113

[a]Source: (42).

but also has severe implications for rural communities serving the farming industry.

Changes in the Demand for Agricultural Products

Another factor contributing to change in the farming industry is a shift in the demand for agricultural products. Changes in both the aggregate demand for farm products and the relative demand for individual farm commodities affect the quantity and mix of resources devoted to agriculture and the earnings of the farming sector.

Hathaway lists five potential sources of shifts in the aggregate demand for farm products (9, p. 132). They are:

(1) Changes in population,

(2) Changes in tastes and preferences,

(3) The development of new uses and/or substitutes for farm products,

(4) Shifts in export demand, and

(5) Changes in the level of income and employment.

Each of these factors has influenced the American farming industry in the last 30 years. The nations population has grown from 130.6 million people in 1939 to 204.3 million in 1970 (42). At the same time, the per capita income of the American consumer increased by 525 percent (42). Concern regarding cholesterol acted to dampen the per capita consumption of certain livestock products, such as eggs and butter, but the introduction and increased use of oleomargarine provided a new market for soybeans. Expansion of livestock production in foreign countries may have diminished the demand for American livestock products while increasing the demand for American feedstuffs.

Per capita food consumption

Shifts in consumer tastes and preferences, the development of substitute uses for farm products or the development of nonfarm substitutes for farm commodities all can affect the per capita consumption of particular farm products. These shifts may alter the aggregate domestic demand for food or may only affect specific farm commodities. In either situation, they will have impacts on agricultural resource use and, in some instances, can result in major adjustments in regional production patterns.

Tables 3 and 4 present indices of per capita consumption for selected livestock and crop products. Table 3 shows that the per capita demand for all animal products grew steadily

Table 3. Domestic per capita consumption of animal products[a]

Year	All animal products	Meat	Poultry	Eggs	Dairy products
1939	84.6	79.3	36.8	92.6	107.2
1940	87.4	84.5	37.9	94.3	107.2
1941	88.7	85.7	41.0	92.1	108.3
1942	89.8	84.8	45.9	93.1	114.4
1943	92.4	88.7	57.0	101.8	109.3
1944	94.5	93.8	51.0	104.0	111.3
1945	95.5	88.3	56.0	117.7	115.0
1946	97.6	92.2	51.6	111.1	120.3
1947	96.1	92.6	47.1	114.3	115.7
1948	92.2	86.6	46.2	116.7	110.2
1949	92.3	86.0	49.5	115.7	110.2
1950	93.8	86.0	53.6	118.5	110.3
1951	92.0	81.9	56.7	120.0	108.6
1952	94.2	86.7	58.3	120.0	108.6
1953	96.1	92.4	58.1	116.7	107.5
1954	96.3	91.7	61.3	115.7	108.5
1955	97.7	95.9	57.6	114.3	109.8
1956	99.5	97.7	64.6	113.7	110.2
1957	96.6	92.5	68.7	111.9	108.5
1958	94.6	87.8	74.2	109.5	107.5
1959	96.9	91.9	76.8	109.0	107.2
1960	95.7	92.3	74.5	103.6	105.7
1961	95.8	91.7	82.0	101.4	104.3
1962	96.2	92.7	80.7	101.0	104.8
1963	97.3	95.7	82.0	98.2	104.1
1964	98.8	98.5	83.8	98.5	104.1
1965	96.9	93.9	89.2	97.0	103.4
1966	98.1	96.1	95.7	97.0	102.0
1967	100.0	100.0	100.0	100.0	100.0
1968	101.5	102.8	98.9	99.0	101.0
1969	101.2	102.2	103.2	98.0	100.1
1970	102.5	104.2	107.8	98.5	99.2
1971	103.8	107.2	108.6	97.1	99.2
1972	103.6	105.3	113.2	94.9	99.9

[a]Source: (51).

Table 4. Domestic per capita consumption of crop products[a]

Year	All crop products	Vegetable fats and oils	Fruits	Vegetables	Potatoes and sweet potatoes	Flour and cereal products
1939	96.0	53.9	110.9	104.0	95.2	122.0
1940	96.4	50.6	108.8	105.1	91.8	123.7
1941	99.1	56.9	110.7	105.6	97.0	124.5
1942	94.9	52.4	97.6	110.3	98.6	125.5
1943	94.4	53.0	86.7	112.0	99.3	139.0
1944	98.6	52.1	98.4	117.0	104.9	127.2
1945	99.5	51.1	104.0	123.6	93.5	134.4
1946	102.0	54.4	114.9	119.3	93.2	132.1
1947	99.3	55.2	112.1	109.3	91.6	118.5
1948	97.3	59.2	107.7	106.2	75.9	117.0
1949	97.1	61.6	107.3	102.7	79.0	116.5
1950	98.1	67.4	103.0	102.4	76.2	115.4
1951	96.5	59.8	105.3	101.8	76.3	118.2
1952	97.7	69.0	107.9	101.4	68.7	116.1
1953	97.2	70.5	105.6	100.2	72.7	113.5
1954	96.6	77.2	104.3	98.6	72.5	111.2
1955	96.1	75.6	103.8	100.2	73.6	105.3
1956	96.3	73.3	105.1	100.0	70.2	103.8
1957	95.3	73.1	105.5	99.4	71.0	102.2
1958	95.1	75.9	100.9	98.2	70.6	103.8
1959	96.7	79.4	104.1	97.6	76.1	103.0
1960	97.1	80.7	102.8	98.9	79.0	102.6
1961	96.4	78.5	99.3	97.7	80.2	101.9
1962	96.5	81.4	98.7	97.2	82.1	101.0
1963	95.9	85.1	90.0	97.0	85.9	100.1
1964	96.4	90.3	90.9	96.7	87.9	100.7
1965	97.6	91.9	94.7	97.8	92.4	100.9
1966	98.6	101.8	95.2	97.5	100.4	99.4
1967	100.0	100.0	100.0	100.0	100.0	100.0
1968	101.0	104.0	97.3	100.4	104.0	100.7
1969	102.0	110.4	100.2	100.7	110.4	101.1
1970	103.1	116.3	102.4	101.2	112.0	98.1
1971	102.8	113.2	102.2	100.8	112.6	98.9
1972	103.8	119.8	99.7	101.7	113.4	97.7

[a]Source: (51).

from 1939 to 1972. In contrast, the per capita demand for all crop products (Table 4) exhibited more fluctuation and grew by a smaller percentage than did the demand for livestock products. By 1972 the consumption of all crop products was only 8 percent higher than in 1939 while the consumption of all animal products had grown by 22 percent in that same time span.

The per capita consumption of each of the four livestock categories presented in Table 3 did not follow the same growth pattern as shown by the index of all animal products. In fact, the per capita consumption of dairy products was 7 percent lower at the end of the period than at the beginning, having reached its highest level of consumption immediately after World War II. This decrease in dairy product consumption between 1939 and 1972 reflects the housewife's shift from butter to oleomargarine during this period, as the consumption of dairy products excluding butter, had actually increased by 23 percent during this period (51).

In the last three decades the per capita consumption of each of the other livestock categories presented in Table 3 registered increases. The consumption of meat products increased steadily throughout the period as higher per capita incomes allowed greater expenditures for beef. The per capita consumption of poultry rose spectacularly in this time period, with the 1972 consumption being three times as great as in

1939. However, the consumption of eggs per person was only slightly higher at the end of the period than in 1939. Per capita egg consumption increased up to and during the Korean conflict but declined steadily thereafter as concern over cholesteral content and changes in consumer's diet habits dampened the demand for eggs.

As noted previously in this section, the per capita consumption of all crop products increased slightly from 1939 to 1972. However, the per person consumption of fruits, vegetables, and flour and cereal products all declined during this time period. The sharpest decline occurred for flour and cereal products. In 1972 the per capita consumption of these products was only 80 percent as large as in 1939.

The consumption of potatoes and sweet potatoes on a per person basis fluctuated during this period but then jumped sharply in the latter years of the 1960's. The per capita consumption of vegetable fats and oils showed the sharpest increase of the crop categories listed in Table 4. This jump in consumption reflects the increased use of soybeans in oleomargarine as well as the substitution of vegetable oils for animal products in cooking.

Per capita demand for cotton

Table 5 presents per capita consumption data for cotton lint during the years from 1939 to 1970. The per capita consumption of cotton lint reached its peak in the war years of

Table 5. Per capita consumption of cotton lint[a]

Year	Per capita consumption cotton lint (lbs.)	Year	Per capita consumption cotton lint (lbs.)	Year	Per capita consumption cotton lint (lbs.)
1939	27.7	1950	30.9	1960	23.2
1940	30.0	1951	31.5	1961	22.2
1941	38.9	1952	28.5	1962	22.5
1942	41.8	1953	27.9	1963	21.4
1943	38.6	1954	25.4	1964	22.1
1944	34.6	1955	26.5	1965	23.1
1945	32.3	1956	25.9	1966	23.6
1946	34.0	1957	23.7	1967	22.3
1947	32.4	1958	22.2	1968	20.7
1948	30.4	1959	24.5	1969	19.4
1949	25.7			1970	18.6

[a]Source: (42).

1941, 1942, and 1943. It declined steadily (except for the years of the Korean conflict) throughout the rest of the period reaching a low of 18.6 pounds per person in 1970. The introduction and popular adoption of man-made fibers contributed greatly to this decrease in the domestic consumption of cotton lint.

Export demands

Hathaway (9, p. 133) notes that flucuations in the quantity of farm commodities exported has been an important source of demand instability for American agriculture. He attributes these fluctuations in export demand primarily to two sources. The first is sharp changes in the available supply of farm commodities produced in foreign nations. The recent crop shortfalls for Russian wheat and the temporary disappearance of the anchovy from the coast of Peru are examples of this source of demand instability (28). The second source he refers to is changes in foreign demand for U.S. farm products. For example, increases in livestock production because of rising per capita incomes in Europe have provided expanded markets for American feed grains. Hathaway's categories do not include reevaluations in currency exchange rates which can dramatically change the effective price of American farm products in foreign markets (27). Also, policy decisions by the federal government can significantly alter the effective foreign demand for American farm products, as when food aid was adopted as a part of foreign policy during the Kennedy-Johnson administrations (8, p. 239).

Table 6 presents data relating to the export of certain U.S. farm products for the 1939-70 period. This data show that total American farm exports have increased sharply, and rather steadily, throughout this period. By 1970 total farm

Table 6. Indices of the quantities of American agricultural products exported from 1939-70[a]

Year	Total agricultural exports	Animal and animal products	Cotton and linters	Grains and feeds	Vegetable oils and oilseeds
1939	26	18	92	13	1
1940	29	14	164	7	4
1941	12	18	32	6	2
1942	22	116	29	5	2
1943	25	151	32	4	5
1944	31	184	32	5	7
1945	30	136	42	7	6
1946	45	137	92	23	3
1947	46	87	99	32	4
1948	41	73	51	36	5
1949	52	66	119	41	14
1950	48	55	145	30	16
1951	48	65	108	37	18
1952	54	56	142	42	18
1953	40	48	76	32	14
1954	42	68	94	25	23
1955	48	94	92	28	32
1956	56	116	56	41	43
1957	77	109	185	54	47
1958	65	91	143	45	46
1959	62	83	79	52	51
1960	79	96	166	60	69
1961	84	98	176	69	65
1962	85	103	119	79	64
1963	84	104	91	79	78
1964	100	140	128	94	82
1965	98	130	113	92	99
1966	107	108	78	117	102
1967	104	101	115	103	95
1968	101	96	101	104	99
1969	92	110	69	85	106
1970	106	101	75	97	148

[a]Source: (42).

exports were over four times larger than they were in 1939.

Although exports of animals and animal products did rise sharply from their 1939 level, this category did not exhibit the same steady increase noted for all agricultural products. Instead the shipment of animals and animal products to foreign markets was very large from 1942 to 1946, in 1956 and 1957, and again in 1964 and 1965. Much of this fluctuation can be linked to changes in the foreign demand for American dairy products (42).

Foreign trade in cotton and linters also was subject to wide variation throughout this period and at the periods end was lower than at its beginning. In fact, 1970 export levels were only 82 percent of 1939 exports. Strong foreign demand for cotton and linters occurred in 1940, during the Korean conflict, in the mid-1950's, and for much of the 1960's.

Exports of both American grains and feeds and vegetable oils and oilseeds have increased substantially during the three decades presented in Table 6. The expansion of trade in these categories is concentrated primarily in wheat, corn grain and soybeans exports. Exports of feeds and grains peaked in the mid-60's reflecting the large overseas deliveries of wheat as food aid in those years. Even though exports of these two categories increased sharply during the period shown in Table 6, this time period does not include the very large exports of wheat, corn grain and soybeans of the last two years. Inclusion of recent data would underscore even more dramatically the potential variability of export demands for farm products.

Major Government Programs to Provide Income Relief for Agriculture

The two preceding sections discussed some of the major factors which have affected the American farming industry. But other forces, both social and political, also acted to induce change in agriculture and in the rural community. One of these forces was federal legislation dealing with commercial agriculture. This section of the report will outline some of the major commodity programs initiated by the federal government to provide support for the farming industry as it adjusted to the many forces affecting it.

In this century one of the earliest and most severe shocks to the American farming community was World War I. Previously farming had been a very labor intensive industry and prices for farm products were relatively high, especially in the 1910-14 period. The farming community was relatively self-contained and the nation was still, to a large degree, rural-oriented. But the war provided new markets for American farm products. This new source of demand acted as a catalyst for farmers to adopt the new technologies, such as mechanical power, which were becoming available. When America entered the conflict, the need for soldiers reduced the available farm labor force. This decrease in farm laborers provided further inducements for the adoption of labor-saving farm technologies and the expansion of farm production.

After the wars end the markets for farm products contracted sharply. A wave of protectionism swept the country further reducing the effective foreign demand for American farm products. Although many farm boys who became soldiers chose to remain in the city, many others returned to the family farm. The result of this simultaneous reduction in demand and increase in the labor force was the appearance of a large amount of excess agricultural capacity. This excess capacity drove farm prices down, causing severe hardships for American farmers (32, p. 69).

In contrast, the general economic climate throughout the 1920's was that of a boom economy. The resulting satisfaction with the market system acted as a deterent to proposals advocating government interference in the marketing process of farm products. Further, the effect of the technological advances occurring in agriculture was not fully appreciated and the overproduction of farm products was commonly viewed as a temporary wartime dislocation (8, p. 85).

As this situation persisted, however, a "farm-bloc" of rural congressmen and farm spokesmen formed to promote relief policies for the farming industry. Much of their legislative effort was directed toward two-price programs such as the McNary-Haugen Bill. These policies were effectively rebuffed, however, by the pro-business administrations of Coolidge and Hoover (40, p. 143).

By 1929, the farm situation had become so critical that the Hoover administration proposed a stabilization cooperative which, through its marketing policies, would act to stabilize farm prices. To this end, a Federal Farm Board was chartered by the Agricultural Marketing Act of 1929 (8, p. 107). No production controls were embodied in this act, however, and eventually the Board suffered a paper loss of over $65 million on the commodities it purchased (26, p. 47).

By this time, of course, the rest of the nations economy had caught up with the farming sector and was in the midst of the Great Depression. In 1933, a major goal of the Roosevelt administration and its Secretary of Agriculture, Henry A. Wallace, was the provision of income relief to farmers. Shaped by this concern for farmers and by the failure of cooperatives to increase farm income, the Agricultural Adjustment Act of 1933 was enacted. This program had five major goals:

(1) Immediate income relief,

(2) Increased farm income,

(3) Production control,[1]

(4) International regulation of wheat markets, and

(5) Expanded exports.

But because this Act used a tax on processors to generate revenue for farmers, the Supreme Court ruled it unconstitutional in the Hoosac-Mills decision on January 6, 1936 (32, p. 71). The Roosevelt administration's response to this decision was to enact the Soil Conservation and Domestic Allotment Act of 1936 as a temporary measure to buoy up farm incomes.

New permanent legislation was enacted in the Agricultural Adjustment Act of 1938. This act incorporated stern production controls and commodity storage in an attempt to reach its overriding objective of parity for farmers. Secretary Wallace championed the concept of the "ever normal" granary to provide grain reserves and more stable farm prices. Of course, farmers tended to look at the "ever-normal" granary more as a mechanism to establish a floor under farm prices in times of overproduction rather than as a price ceiling in times of scarcity.

The outbreak of war in Europe, and the eventual involvement of America in it, again provided a strong stimulus to

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[1]The production control aspects of this program would be made much easier because of the severe drought which gripped parts of the nation from 1933 to 1936.

American agriculture. Farm surpluses which previously had been a political burden now became a valuable resource. As in World War I, reductions in the available farm labor supply helped to speed the adoption of new agricultural technology. Farm prices were raised to levels greater than 100 percent of parity to encourage greater production. During the war, Congress guaranteed prices at 90 percent of parity levels on basic commodities for two years after the end of the war to cushion the reconversion of the farm community to peacetime.

But by this time, some agriculturalists had adopted the view that price supports were not the proper mechanism to preserve the family farm. A spokesman for this view was Theodore Schultz, who in 1946 criticized "...the belief that solving the production problems in agriculture perforce solves the welfare problems of farm people" (35, p. 451). This view was incorporated in the Brannon Plan which would have provided an income subsidy to farmers when farm income was low but would have limited the maximum amount any individual farmer could receive. This plan although considered, was never enacted into law by Congress.

Instead, rigid price supports pegged at high levels were the norm during Truman's administration. These support prices led to large surpluses of the basic commodities when the Eisenhower administration took office. Eisenhower's Secretary of Agriculture, Ezra Benson, entered his term in office with the primary objective of removing governmental influences from agriculture. He felt that the market would act to balance supply and demand and should be allowed to operate without government interference.

By 1956, droughts in some areas, coupled with national overproduction and the fall elections, forced the administration to enact programs to provide income relief to farmers. The resulting Soil Bank program provided for short-term relief through the Acreage Reserve program and long-term production control through the Conservation Reserve. Although the Acreage Reserve did provide additional income to farmers, it was ineffective as a production control measure because of lack of administration support. The Conservation Reserve failed because of the intense political hostility it generated. Since it allowed land retirement to be concentrated in particular regions, businessmen and politicians in those regions were very distraught with this program and pressed for its termination.

Because of the previous administration's ideological aversion to production controls, "Mountains of surplus wheat had become symbolic of the national 'farm problem'" (8, p. 235) when the Kennedy administration took office. The philosophy of Secretary of Agriculture Freeman was radically different from that of his predecessor. He and his staff believed that government action could be used to relieve the distress of the American farmer. Hadwigger lists five objectives of this administration (8, p. 239):

(1) Raising farm income,

(2) Reducing government storage costs,

(3) Constructive use of the farm abundance,

(4) Agricultural development, and

(5) Efficient use of land resources.

By 1964, the administration had settled on voluntary controls[1] and expansion of foreign food aid to accomplish these goals. These voluntary controls involved land retirement on a partial farm basis and government payments to farmers who withdrew their land from production. In addition, provisions were continued for government storage and direct price supports for surplus production of basic commodities. The basic concepts of this program, with alterations in some provisions, was continued through the decade of the 1960's.

In 1973, the Agriculture and Consumer Protection Act was enacted (43). This program incorporates "target prices" for the basic farm commodities; wheat, feed grains and cotton. It provides for subsidies to farm producers if the market prices of these commodities fall below the base year prices. (An inflation factor is also incorporated into the program.) In addition, the Secretary of Agriculture can call for

[1]Voluntary controls were chosen after the defeat of mandatory controls in the wheat referendum of 1962.

production controls if the supply of these commodities exceeds their demand.

Of course, popular concern for the last year has not been directed towards the floor price, but rather towards the maximum price of farm products. The sharp jump in farm prices which has recently occurred is due in large part to tremendous increases in the foreign demand for American farm products. This increase in foreign trade is the result of both increasing incomes in some foreign countries and production short-falls in others. If this foreign demand should sharply weaken, however, the provisions of the present farm program may, again, be especially critical to farmers and to the federal budget.

So far in this section, we have provided a brief overview of the attempts of government to provide relief for the farming industry. A major force in these attempts was the political considerations shaping these legislative efforts. Heinz delineates four features of the political scene temporing farm legislation (17, pp. 186-188):

(1) Inter-commodity conflicts (livestock vs. feed grains)

(2) Intra-commodity conflicts (long vs. short staple cotton)

(3) Political variables (interests of key congressional leaders)

(4) Political party philosophies (Democrats favoring price supports---Republicans opposing)

Another factor used to justify governmental relief for agriculture is that many of the causes of distress in the farm community are initiated in the nonfarm sector. Wars, famines in other lands, technological breakthroughs, actions of foreign governments, shifts in consumer preference, and the weather are only a few of the many factors which can have dramatic effects (both good and bad) on individual farmers but over which he has almost no control. Recognition by the American public of this aspect of farming partially explains the past willingness of the public to contribute to the welfare of the agricultural sector.

Changes in Average Farm Size

In a previous section, indices were presented which documented the tremendous changes in productivity that have occurred in American agriculture in the last three decades. These productivity increases allowed the average size of farms to grow substantially. At the same time increases in the size of farms contributed to further increases in productivity. For example, as more and larger machines were developed an individual farmer could increase the amount of land he could effeciently manage. However, a larger farming unit provided additional impetus for the farmer to adopt even larger, more efficient equipment. Table 7 presents both the number of farming units which existed in American agriculture from 1949 to 1970 and the average size of those units. Farm numbers declined steadily throughout this period---from 5.7 million in 1949 to 2.9 million in 1970. This almost 50 percent decline in farm numbers was offset by a 90 percent increase in average farm size---to 383 acres in 1970.

The shift to larger, more commercial farms is partially explained by the net income data in Figure 1. While the per farm net income of farms in the lowest sales class rose only slightly during the 1960's, per farm net income for farms in the highest sales class increased quite substantially. For farms with sales of less than $10,000, net farm income in 1970 had increased by only $109 over the $1,588 earned in 1960. For those farms with sales of over $40,000, however, per farm net income had risen by 35 percent during the 1960's---from an average of $18,955 in 1960 to $25,664 in 1970.

As farms have grown larger, the relative importance of the larger farms has also increased. The data graphed in Figure 2 show the importance of differing sizes of farms in commercial agriculture. Although farms with less than $10,000 in sales comprised 62 percent of American farms in 1970, they earned only 10 percent of the cash receipts and 20 percent of the realized net income earned in farming that year. In contrast, farms with sales of more than $40,000 earned 53

Table 7. Number and average acreage of farms in the United States[a]

Year	Number (1000)	Average acreage per farm (ones)
1949	5,722	202
1950	5,648	213
1951	5,428	222
1952	5,198	232
1953	4,984	242
1954	4,798	251
1955	4,654	258
1956	4,514	265
1957	4,372	273
1958	4,233	280
1959	4,105	288
1960	3,962	297
1961	3,821	306
1962	3,685	315
1963	3,561	324
1964	3,442	333
1965	3,340	342
1966	3,239	351
1967	3,146	360
1968	3,054	369
1969	2,971	378
1970	2,924	383

[a]Source: (67).

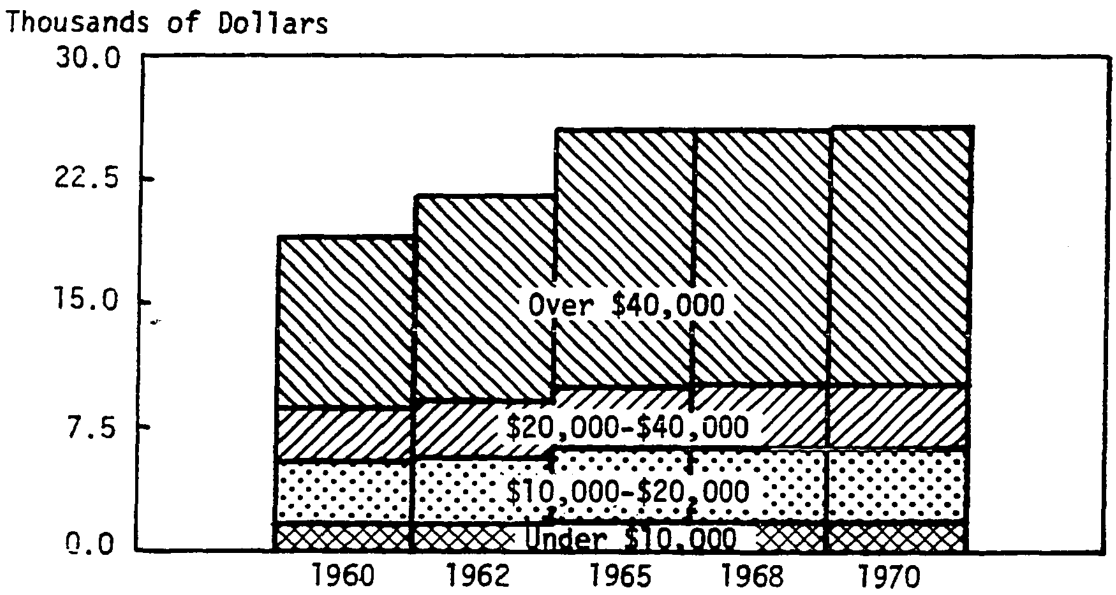

Figure 1. Realized net income per farm by sales classes

Source: (58).

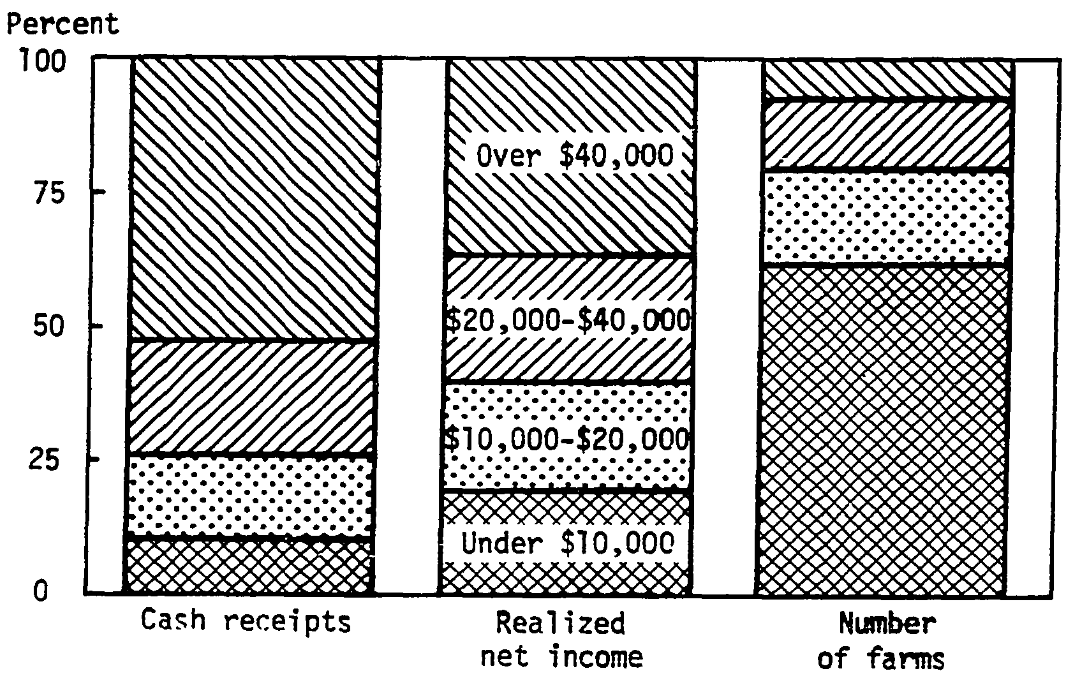

Figure 2. Farms, cash receipts, and net income by sales classes, 1970 Source: (58).

percent of the cash receipts and 36 percent of the realized net income of American agriculture but accounted for only 8 percent of its farming operations.

While the changes in productivity and demand discussed previously were major factors in the expansion of the individual farming operation, they were not the only forces at work. Public policies, such as the ones discussed in the previous section, may have also worked to encourage the commercialization of agriculture. These programs provided increased capital to farmers with which they could purchase additional capital and further expand their operations (33, p. 74). Quance and Tweeten describe the process occurring under land diversion programs (31, p. 36):

> Government programs result in more than the adequate commercial farmer expanding his unit to compensate for land diverted. Instead the farmer expands his unit even more because of the security and capital provided by the government program. The adequate farmer finds he can make a convincing case to himself and his banker that a larger, more adequate machine is feasible--he can efficiently use the machine and can pay for it. With it he is able to farm the land of his neighbor who may retire or take a nonfarm job.

Effects on the Rural Community

Previous sections have outlined some of the major factors affecting the American farming industry throughout the last three decades. But the resulting changes did not affect only the farming sector. Rather they had significant implications for those rural communities serving agriculture and for those urban communities receiving displaced farm workers.

Figure 3 graphically depicts the relationship between average farm size and farm population. While the number of farms fell from over six million in 1940 to less than three million in 1970, the average size of farm grew from less than 200 acres in 1940 to 383 acres in 1970. During this same period the farm population declined by more than two-thirds. The farm population which had numbered over 30 million in 1940 was slashed to less than 10 million people in 1970.

As the farm population dwindled, the need for services in many rural towns also decreased. This decline in the demand for services, coupled with the increased mobility of rural people, resulted in severe economic hardship in many communities (5, p. B-13). Mayer directly relates these hardships to changes in the agricultural sector (24, p. E-4):

> ...the changing structure of agricultural production has significantly altered the flows of money in rural towns. More money flows to sources in urban areas and less remains to provide jobs in rural towns. As mechanization of agriculture increased and as capital intensification occurred, rural towns have experienced a slow drawdown of economic vitality.

The nation has slowly begun to realize that the nonfarm sector of rural communities has borne a major cost of the transformation of American agriculture. The Rural Development Act of 1972 represents an explicit realization that the public should concern itself with their plight. And under Title V of

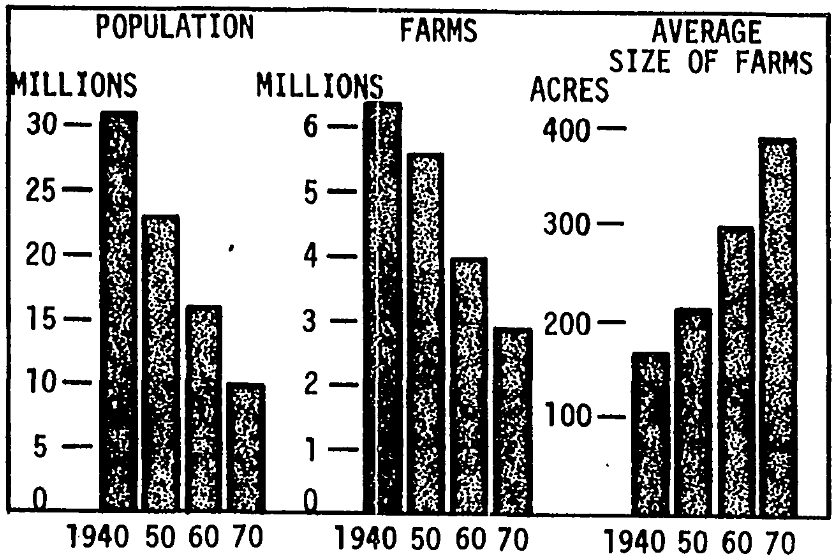

Figure 3. Farm population, farms, and farm size: 1940-1970

Source: (68).

the Act, Rural Development and Small Farm Research and Education, a linkage is hypothesized between average farm size and the welfare of rural communities (14).

Concern for the plight of rural communities is commonly categorized under the topic of rural development. Although this topic is not new to economics, Waters lists four new features of present-day rural development (73, p. 9). These four features can be paraphrased as:

1) Concern with the entire nonmetropolitan part of the nation---not just farms and villages;

2) Concern with more than poverty and depressed areas;

3) Concern with improving the conditions in rural America so that people will have the opportunity to remain there; and

4) Concern over the concept that massive urbanization is an ironclad law of economics which can't be tampered with.

While rural development involves more than just economics, Tefertiller defines its major economic goals, "... to be expanding job opportunities, increasing incomes and improving the distribution of income, and providing public services and facilities to rural people" (41, p. 771). He divides the rural area into two parts---those with a declining population and those with an increasing population---to focus on their separate needs.

Tefertiller characterizes those rural areas with an increasing population as being not largely dependent upon the agricultural industry, although it may still be an important part of the economy of the area. In these areas, the need for public services and the desire of its residents to attain urban conveniences in a rural setting may be a more important issue than promoting additional off-farm employment.

The concern for providing viable employment opportunities, however, may be the central issue in those rural communities with declining populations. The severity of the plight of these areas is evidenced by the fact that the proportion of the nation's people living in rural areas has dropped from 36 percent in 1950 to 26.5 percent in 1970 (67). Kaldor notes that for an economic turnaround to occur in any particular rural community, it must have a basis for its economic existence or revival (20, p. C-1). Rural industrialization and recreation have been suggested as foundations for the economic revival of rural communities. But Wadsworth suggests that the majority of rural communities do not possess the intrastructure necessary to attract new industries into their towns (72, p. 65). And Webster and Grafton point out that the recreation potential of rural areas is limited to those communities with unusual natural or cultural resources (75, p. O-1). Considerations such as these support Bentley's claim that a rural development program which fails to recognize the role of agriculture as a major industry in most rural areas is doomed to failure, especially in those with a declining population (2, p. 5).

Objectives

While American agriculture has already undergone far reaching changes, trends underway indicate that change and uncertainty may continue to characterize the farming industry. These changes will continue to have important economic and social impacts on agriculture and the rural communities surrounding it. The objective of this study, then, is to analyze a major segment of the American agricultural industry under different alternatives of future structure and to indicate some of the impacts of these alternative futures on variables directly related to farming and the sectors surrounding it. These futures are all based on projection to the year 1980.

Agricultural export levels are a major parameter differentiating the alternative futures discussed here. One view of future exports supposes that the growth in agricultural exports will follow historic long-run trends. Under this view export levels are projected to be higher than in the late 1960's but do not exceed recent levels for all farm commodities. A second view of future exports requires that American agriculture produce at peak capacity, with production in excess of domestic demand then exported.

To investigate the effect of different farm-size structures in American agriculture, three alternative futures with different specifications as to average farm size are examined. These three alternatives are compared under the export assumption where agriculture would be operating at peak capacity.

Also for the trend level export future, the impact of two methods of implementating a "target price" farm program are compared. One alternative uses a direct payment to farmers; the other uses acreage quotas to force market prices to the "target" level. The price levels specified in the Agriculture and Consumer Protection Act of 1973 are used as the "target" prices for this comparison (43).

In total, outcomes under seven separate alternatives, differentiated by the three parameters just discussed (export levels, farm size, and target prices), are compared in this study. The seven alternatives are explained more fully in a later section. To indicate the cost and benefits of these alternative situations to different economic groups, the values of certain key variables are estimated under each situation. Some of these variables apply directly to commercial agriculture but others relate to impacts on nonfarm sectors of the economy. Variables presented in the study which relate directly (but not exclusively) to commercial agriculture are: the quantity and location of production of major crops, the input requirements of this production, prices received for those crops, and net farm income---both for the entire farming sector and per commercial farm. Since consumers are the final beneficiaries of farm production, estimates are made of consumer expenditures for food under various situations. To indicate the potential environmental impact of the different alternatives, an estimate of gross soil-loss is calculated for each alternative. The final variable presented relates the value of output of the major crop commodities to the total income generated throughout the nation by the production of these commodities.

The remainder of this report describes the economic models used in this study, explains the methods used to derive the data comprising these models, and compares the results of the seven alternatives analyzed. Chapter II describes the linear programming model which provides the base data for the analysis. Chapters III and IV present the methods and procedures used to calculate the input data for the programming model. Outcomes for each of the model alternatives are compared in Chapter V.

CHAPTER II. MODEL FORMULATION

Both a verbal and a mathematical discussion of the programming model used in this study are presented in this chapter. The various regional concepts adopted for the analysis are also discussed here. To investigate the impact of variations in the farm-size structure of agriculture, definitions of farm-size categories are required. These definitions are described in this chapter of the manuscript. Finally the seven model alternatives used in the analysis are detailed in this chapter.

Verbal Description of the Programming Model

A linear programming model is used to estimate the base data for this analysis. This national model describes the wheat, feed grains, soybeans, and cotton production sectors of American agriculture. It incorporates an interregional comparative advantage production sector, a transportation submodel and the fulfillment of consumer demands in 31 market or consuming regions. Costs of production, crop yields and consumer demands for the model are based on parameters estimated for the year 1980.

The programming model minimizes the cost of producing its endogenous commodities (wheat, feed grains, soybeans, and cotton) in 150 rural areas and of transporting them among 31 consuming regions. The model simulates production equilibrium in that the supply price of each crop commodity must cover the cost of producing that commodity in each rural area. Market equilibrium is simulated in that the quantity of each commodity supplied must equal the demand for that commodity in each consuming region.

Demands for spring and winter wheat, feed grains, and oilmeals are specified for 31 consuming regions. The demand for cotton lint, however, is specified only at the national level. The demand levels specified for these five commodities (spring and winter wheat, feed grains, oilmeals, and cotton lint) are the summation of their estimated use as seed, livestock feed, domestic food, industrial inputs, and exports--- both in raw and processed forms.

Transportation activities are defined to allow the production of a commodity in one consuming region to be used to satisfy the demand for that commodity in another consuming region. Potentially there exists 31 * 30 = 930 transportation activities for each of the commodities for which regional demands are specified or a total of 3,720 potential transportation activities. Patterns of historic grain movement and regional production potentials are used to reduce the number of transportation activities to 202 for spring wheat, 467 for winter wheat, 458 for feed grains and 476 for oilmeals. Rail rates reflect transportation costs between all consuming regions. No transportation costs are defined from the rural area to the center of its consuming region.

The production and demand for spring and winter wheat, feed grains, and oilmeals are determined on a feed unit basis. Use of the feed unit concept allows the aggregation of the four feed grain crops (barley, corn grain, oats and grain sorghum) to a single commodity. It also allows the possibility of substitution of wheat for feed grains in livestock feeds, if the relative prices of the two commodities so dictate. Further, it allows the demand for oilmeals to be satisfied by the production of either soybean oilmeal or cottonseed oilmeal.

The programming model contains 275 equations and 2,061 real variables. Land in the 150 rural areas and demands specified by the 31 consuming regions (plus the national cotton lint demand) serve as constraints for the equations. The real variables include crop production, wheat-to-feed grain transfer and transportation activities.

Output of this programming model is used to provide data regarding the location of production and supply prices for feed grains, wheat, soybeans, and cotton for each of the alternatives. By expressing the model in its algebraic form, the method in which this information is obtained is more readily apparent. In this cost minimization model, the objective of the production problem is to find a set of x's such that the function:

$$f(c) = cx \tag{2.1}$$

is a minimum subject to the following restraints:

$$Ax \geqq b \tag{2.2}$$

$$x \geqq 0 \tag{2.3}$$

where:

x is a column vector of production, transfer, and transportation activities;

c is a row vector of unit costs for those activities;

A is a matrix of transformation coefficients; and

b is a column vector of resource restraints and demand requirements.

The allocation question is resolved using the system represented in Equation 2.1, 2.2 and 2.3. The pricing question is solved using the dual formulation of that system. The dual problem can be described as:

$$\text{Maximize:} \quad g(p) = b'p \tag{2.4}$$

subject to:

$$A'p \leq c' \tag{2.5}$$

$$p \geqq 0 \tag{2.6}$$

where:

p is a column vector of land rents and supply prices for the products and

b, A, and c are defined previously.

Because of the complexity of the wheat, feed grains, soybeans, and cotton sectors of the American economy, it is necessary to make several simplifying assumptions to formulate this programming model. While these assumptions detract from the realism of the analysis, they allow the formulation of a model which can attain the goals of the study. The following list presents basic assumptions necessary to allow that formulation:

1. There are n unique, spatially-separated and inter-dependent producing regions (called rural areas) with many producers of at least one of the crop activities (wheat, feed grains, soybeans, or cotton).
2. Constant returns to scale for each farm-size structure exist in each rural area for each crop.
3. Total production is limited by the availability of land.
4. Within each rural area, land is homogeneous and substitutable between crops as permitted by the following restraints:
   a) An agronomic restraint on the maximum number of acres that can be devoted to soybeans and
   b) A minimum requirement as to the number of acres devoted to each crop. This requirement is set at 50 percent of each crops 1969 acreage in each rural area for six of the seven alternatives

analyzed. In the seventh, this restraint is removed to allow complete resource mobility.

5. Within each rural area, each unit of the feed grain activity is composed of the same proportion of barley, corn grain, oats, and grain sorghum.
6. There exists m spatially-separated and interdependent consuming regions each possessing demands for spring and winter wheat, feed grains, and oilmeals.
7. The demand for cotton lint can be adequately described with only a national demand restraint.
8. Demands for the crop commodities are determined exogenously of the programming model.
9. The feed unit equivalent is an adequate conversion measure for all of the commodities (except cotton lint).
10. No regional quality differentials exist for any of the commodities.
11. Railroad transportation rates adequately reflect the cost of transporting the commodities for which regional demands are specified.
12. The transportation industry has the capacity to transport the quantity of commodities determined in any model alternative.
13. Current demand for the model commodities must be met from current production.

14. Least cost production reasonably describes the goals of society with respect to these production activities.

In addition to the 14 assumptions listed above, the usual assumptions of linear programming apply to the model (11). The activities in the model must be linear and additive. This means that when two or more are used, the sum of their individual products must equal total production. All products and factors are assumed to be infinitely divisible. In addition, the number of resource restraints and alternative activities must be finite. Finally, it is assumed that resource supplies, input-output coefficients, and input prices are known.

Mathematical Structure of the Model

The mathematical structure of the model varies for only one of the seven alternatives analyzed. Except for Alternative E, the factors which vary between the alternatives are the assumptions concerning the value of the model parameters; either export levels, farm-size structures, or government farm programs. For Alternative E, however, the restraints on resource mobility (the 50 percent lower bounds) are relaxed to allow complete resource mobility.

The basic model can be described as follows, where Equation 2.7 is the objective function to be minimized,

$$f(c) = \sum_{i=1}^{150} \sum_{j=1}^{4} C^{s}_{ij}\, x_{ij} + \sum_{m=1}^{31} \sum_{r=1}^{2} P_{mr}\, w_{mr}$$

$$+ \sum_{f=1}^{31} \sum_{l=1}^{31} \sum_{r=1}^{4} T_{flr}\, z_{flr} \qquad (2.7)$$

where,

C^{s}_{ij} is the cost per acre of producing the j-th crop activity in the i-th rural area for farm-size structures (j = 1,2,3,4 for wheat, feed grains, soybeans, and cotton, respectively);

x_{ij} is the number of acres of the j-th crop activity in production in the i-th rural area;

P_{mr} is the cost per ton of transferring the r-th kind of wheat to feed grains in the m-th consuming region (r = 1,2 for spring and winter wheat, respectively);

w_{mr} is the tons of the r-th kind of wheat transferred into feed grains in the m-th consuming region;

T_{flr} is the cost of transporting one ton of the r-th commodity to (from) the f-th demand region from (to) the l-th demand region ($f \neq l$; r = 1,2,3,4 for spring and winter wheat, feed grains, and oilmeals, respectively;

z_{flr} is the tons of the r-th commodity transported from (to) the f-th demand region to (from) the l-th demand region.

Production of the crop commodities is restrained by the total cropland available in each rural area, Equation 2.8,

$$L_i \geqq \sum_{j=1}^{4} x_{ij} \qquad (i = 1,2,\ldots,150) \tag{2.8}$$

while the production of soybeans is additionally restrained by an agronomic restraint, Equation 2.9,

$$x_{i3} \leqq A_i L_i \qquad (i = 1,2,\ldots,150) \tag{2.9}$$

where,

L_i is the total acreage of land available for the four crop commodities in the i-th rural area;

A_i is the proportion of the total amount of land available to soybeans production in the i-th rural area (A_i = .5 for all rural areas except those in Arkansas, Louisiana and Mississippi where A_i = .7) and;

x_{ij} is defined as before.

In addition to the upper limits on production in Equations 2.8 and 2.9, minimum production restraints are imposed in each rural area as in Equation 2.10,

$$x_{ij} \geqq B_{ij} \qquad (i = 1,2,\ldots,150,\ j = 1,2,3,4) \tag{2.10}$$

where B_{ij} is 50 percent of the acreage of the j-th crop harvested in the i-th rural area in 1969 and

x_{ij} is defined as before.

Equation 2.10 is not imposed in Alternative E (see section on alternatives defined).

Equation 2.7 is minimized subject to the following additional linear demand restraints:

$$D_{m1} \leqq \sum_{i=1}^{n} Y_{i1}\, x_{i1} - w_{m1} \pm \sum_{f=1}^{31} z_{mf1}$$

$$(m = 1,2,\ldots,31;\ f \neq m) \tag{2.11}$$

$$D_{m2} \leqq \sum_{i=1}^{n} Y_{i2}\, x_{i1} - w_{m2} \pm \sum_{f=1}^{31} z_{mf2}$$

$$(m = 1,2,\ldots,31;\ f \neq m) \tag{2.12}$$

$$D_{m3} \leqq \sum_{i=1}^{n} Y_{i3}\, x_{i2} + w_{m1} + w_{m2} \pm \sum_{f=1}^{31} z_{mf3}$$

$$(m = 1,2,\ldots,31;\ f \neq m) \tag{2.13}$$

$$D_{m4} \leqq \sum_{i=1}^{n} Y_{i4}\, x_{i3} + \sum_{i=1}^{n} Y_{i4}\, x_{i4} \pm \sum_{f=1}^{31} z_{mf4}$$

$$(m = 1,2,\ldots,31;\ f \neq m) \tag{2.14}$$

$$D_5 \leqq \sum_{i=1}^{150} Y_{i5}\, x_{i4} \tag{2.15}$$

where,

n is the number of rural areas in the m-th consuming region,

D_{mr} is the tons of the r-th commodity demanded in the m-th consuming region (r = 1,2,3,4 for spring wheat, winter wheat, feed grains, and oilmeals, respectively);

D_5 is the national demand for cotton lint (in 480-lb. bales);

Y_{ir} is the yield in tons (except for cotton lint which is in 480-lb. bales) of the r-th commodity in the i-th rural area (r = 1,2,3,4,5 for spring wheat, winter wheat, feed grains, oilmeals, and cotton lint);

x_{ij}, w_{mr} and z_{flr} are defined as before.

Finally we have the usual nonnegativity assumptions of linear programming:

$$x_{ij} \geqq 0; \; w_{mr} \geqq 0; \; z_{flr} \geqq 0. \tag{2.16}$$

Regional Delineations

Three regional concepts are utilized in this study. The least aggregated type of region defined is the rural area. Within the continental United States, 150 rural areas have been delineated (Figure 4) for which crop production activities

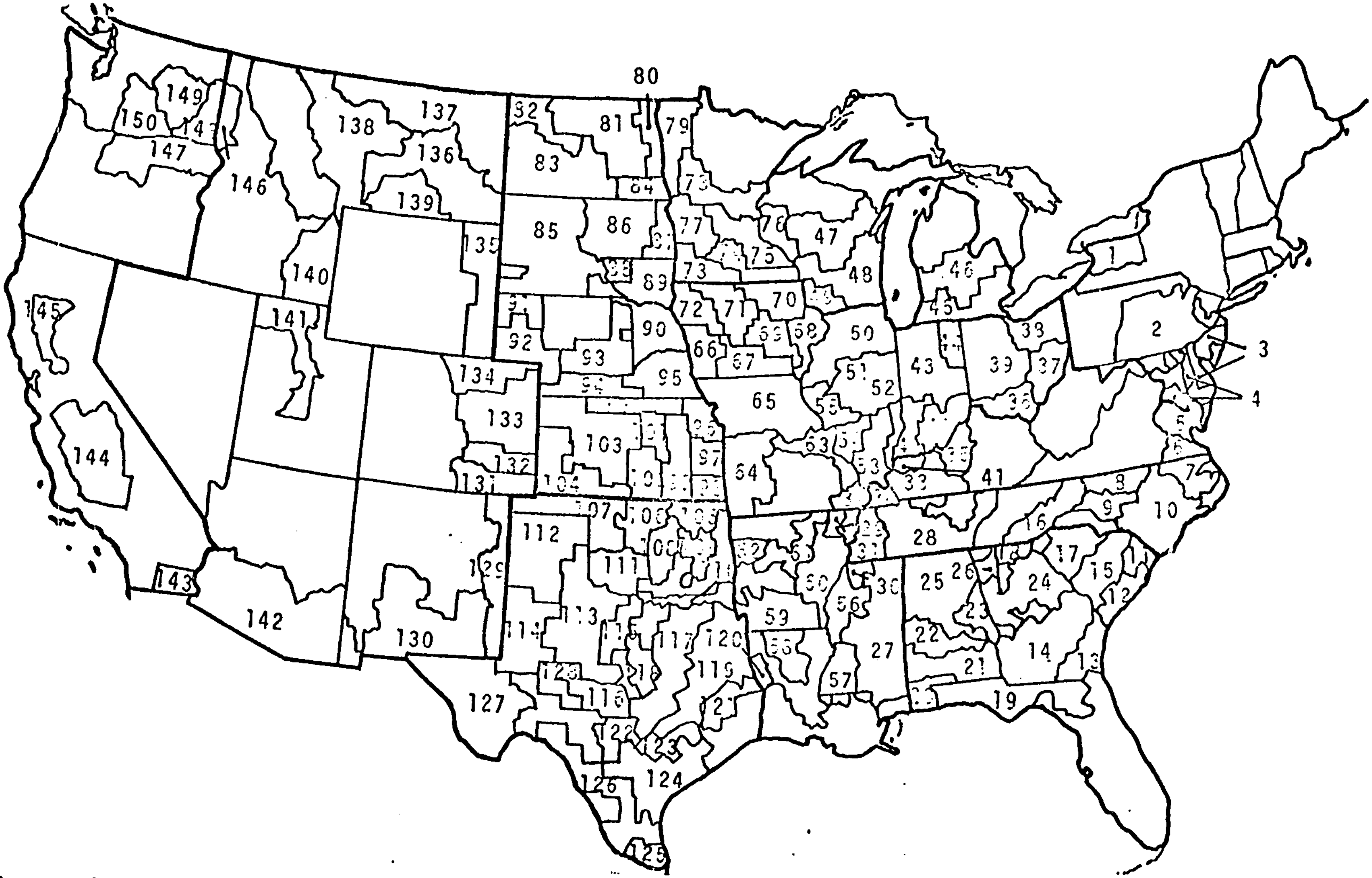

Figure 4. Location of rural areas used in this study

are defined. These rural areas are defined to be internally homogeneous with respect to production possibilities. Factors considered to determine these production possibilities are soil type, climate, historic yields, and production costs.

These 150 rural areas have evolved from the 122 producing areas originally defined by Egbert (4). Later studies by Skold (37) and by Whittlesey (76) subdivided the 122 areas into 144 so that each producing (rural) area was contained entirely within its market (consuming) region. Later studies further subdivided certain of the 144 areas to emphasize production in selected regions (13). The result of this evolution is the 150 rural areas utilized here.

The 150 rural areas are contained within the continental United States but do not completely encompass its entire land base. The areas not included in the 150 rural areas (called White Areas) accounted for only 2 percent of the 1969 production of the four commodities endogenous to the programming model (71). In this analysis, production from these White Areas is held equal to their 1969 production and the demands specified for the programming model are reduced to account for that production.

In the programming model thirty-one separate consuming (or demand) regions (Figure 5) are defined for winter and spring wheat, feed grains, and oilmeals. These 31 consuming regions follow state boundaries and are composed of either one

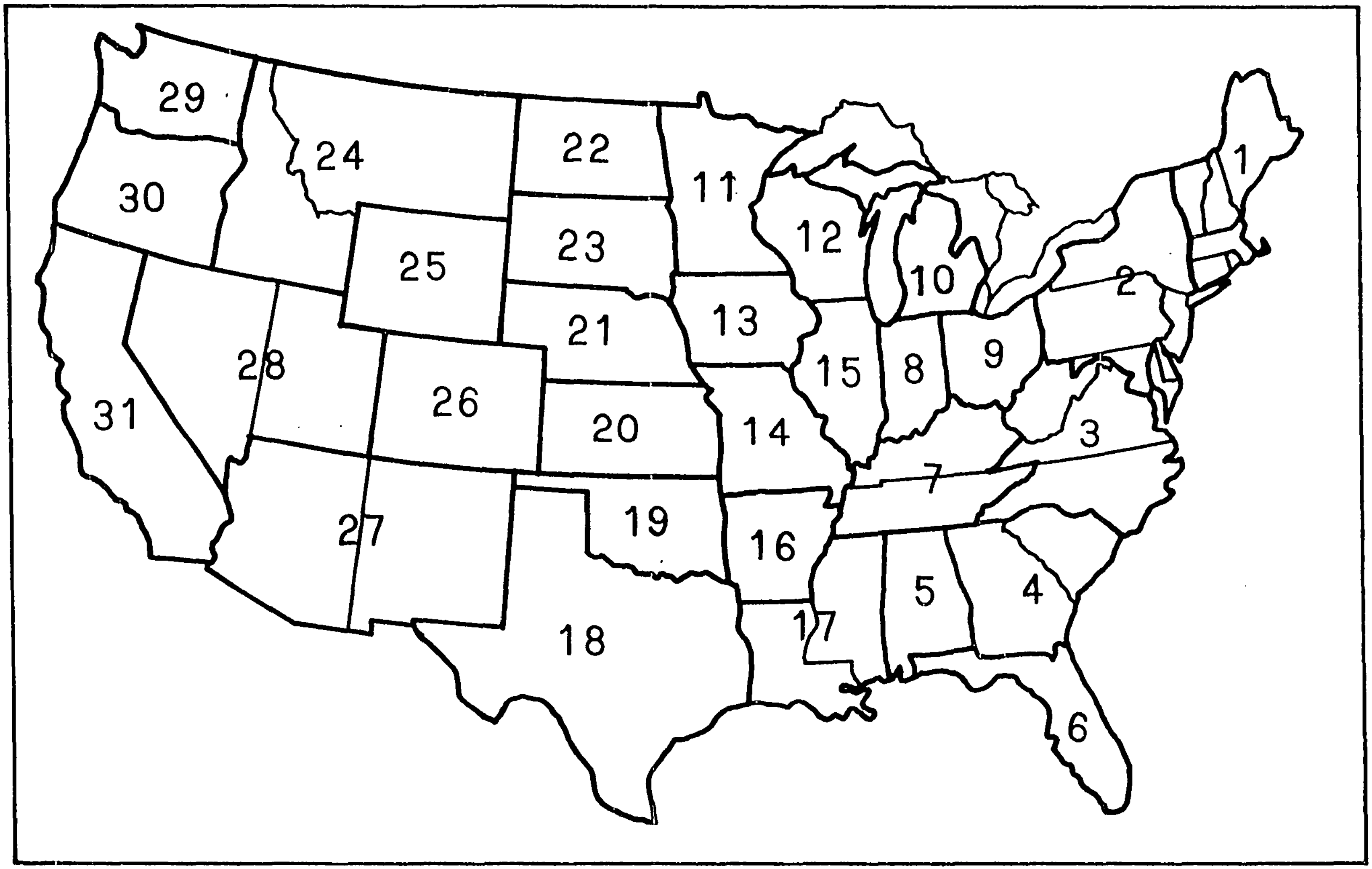

Figure 5. Location of consuming regions used in this study

state or aggregations of several states. The demand for cotton lint, however, is specified only at the national level.

The third regional concept used in this study is the farm production region. The ten farm production regions (outlined in the darker lines of Figure 4) entirely encompass the continental United States. Each rural area and each consuming region is entirely contained in one farm production region. Many of the results of the analysis are presented at the ten farm production region level.

Farm-Size Definitions

In this study, different assumptions as to the average size of individual farming operations are incorporated within the programming model to indicate the possible effects of different agricultural structures on both farm and nonfarm sectors. To examine these assumptions, productive coefficients for three distinct farm-size categories have been developed from data reported by Eyvindson (6). These three categories are referred to as the small-, medium-, and large-farm structures. These farm structures are defined on the basis of value of sales so the average acreage for each farm-size structure can vary with the type of farming operation existing in different regions of the nation. Coefficients for a fourth structure, which reflects a farming industry composed of a mix of farms from each of the three distinct farm sizes, have also been developed.

Production coefficients of the small-farm structure represent the technology of commercial farms with gross farm sales of no more than $10,000. This category corresponds to farms in economic classes IV and V of the United States Bureau of the Census. Nationally, commercial farms in this category had an average size of 232 acres in 1969 (71). Farms in this group generally would be considered too small to provide an adequate family income if the family was dependent on farming as its sole income source. In 1969, 41 percent of the farm operators in this category were employed in off-farm work for more than 100 days of that year (71).

Production coefficients for the medium-farm structure are representative of commercial farms in economic classes II and III of the Census Bureau. Farms in this category have gross sales of more than $10,000 but no more than $39,999. The average farm in this grouping was 520 acres in size and had $20,597 in gross farm sales in 1969 (71).

Production data for the large-farm structure characterize farms in economic class I, gross sales of more than $40,000, of the Census Bureau. For the nation, these farms averaged 1,603 acres and $113,552 in gross sales in 1969 (71). Farm operators in this group are highly commercial and could depend entirely on their farming operation for their family income.

Since American agriculture is not expected to be composed entirely of small, medium, or large farms in 1980, the typical-farm structure has been developed. This structure provides a base situation to compare with the alternatives incorporating coefficients of one of the three distinct farm-size categories. This category represents the cost structure and productive technology of farming if recent farm-size trends were to continue to 1980. Average farm size for this structure would be similar to the average under the medium-farm structure. However, productive coefficients of each of the three farm-size categories (small-, medium- and large-) are incorporated within the typical-farm structure.

Alternatives Analyzed

The major goal of this study is to examine the implications of alternative future situations assuming different values for certain key parameters. Seven model alternatives combining different export, farm-size structure, and government program assumptions are compared for 1980. These seven alternatives and their underlying assumptions are detailed in Table 8.

For six of the seven alternatives, complete resource mobility is not allowed in the programming model. Instead, each of the models 150 rural areas is required to have at least 50 percent as many acres of each of its commodities

Table 8. Alternative situations analyzed in this study

	Base alternative	Maximum exports				Maximum number of farms	
Model alternatives	A	B	C	D	E	F	G
Export level	trend	maximum	maximum	maximum	maximum	trend	trend
Farm-size structure	typical	typical	medium	large	large	medium	medium
Government farm programs	none	none	none	none	none	direct payments	acreage quotas
Restraints on resource mobility	50% lower	50% lower	50% lower	50% lower	none	50% lower	50% lower

(wheat, feed grains, soybeans, and cotton) in production as it did in 1969. This procedure reflects the assumption that some of the inputs used in farming can't be quickly transferred to the production of other farm commodities or be quickly employed in alternative nonfarm occupations. For example, if a farmer has already invested in the equipment necessary to produce cotton, he may not immediately be able to shift to soybean production--even though soybeans would be more profitable for that farmer if he possessed the equipment necessary to grow soybeans. Therefore, the 50 percent minimum acreage restraints are used in the programming model to reflect constraints on resource mobility. No resource restraints are included in Alternative E, however, to provide an indication of the most efficient production pattern available in the model.

Estimates of crop exports for the trend and maximum export levels are presented in the section on derivation of demand coefficients. Briefly, trend level exports are based on the long-run growth of foreign trade from 1949 to 1971. In contrast, foreign markets are assumed under the maximum export case to purchase any American crop production in excess of domestic demands.

Alternative A, combines trend level exports and the typical-farm structure (farms of all three size categories). This alternative can be used as a benchmark solution for comparison with the other six situations.

Alternatives B, C, D, and E all incorporate the maximum export level. Alternatives B, C, and D, which contain differing farm structures, reflect the impacts of different farm sizes under full capacity production. Alternatives D and E both incorporate the large-farm structure but Alternative E has no restraints on location of production and Alternative D contains the 50 percent restriction. Therefore, comparison of these two situations provides an indication of the impacts of the 50 percent resource restraints.

Alternatives F and G both combine trend level exports and the medium-farm structure. These two situations compare the effect of two methods of implementing a "target" price program. Under Alternative F market forces are allowed to determine the quantity and location of production and the prices farmers receive. Direct payments to farmers are necessary under this scheme to insure that farm prices equal "target" price levels. For Alternative G, however, acreage quotas are imposed to force the market determined price of feed grains, wheat and cotton to be equal to "target" price levels. (These acreage quotas are based on 1969 farm program allotments.)

CHAPTER III. DERIVATION OF DEMAND DATA

In this study, demand quantities based on 1980 parameters are estimated for winter and spring wheat, feed grains, oilmeals, and cotton lint. Demands for winter and spring wheat, feed grains, and oilmeals are the summation of their projected use as agricultural inputs, industrial inputs (including domestic food), and exports. Cotton is grown to satisfy domestic and foreign demand for cotton lint. The cottonseed oilmeal which is a byproduct of lint production substitutes for soybean oilmeal, thereby reducing total oilmeal demands.

In each rural area, the estimated per acre yield of each commodity was reduced by the state per acre seed requirement of that commodity to account for seed demand for these commodities (42). Reflecting seed demand in this manner forces the seed requirement to be satisfied in the rural area in which production occurs. In other words, a commodity cannot be transported from one region to satisfy seed demands in another region of the model.

In this section, the processes used to develop the demand sector of the model are presented. First, the domestic demand component for each commodity will be presented in the following order: feed grains, wheat, oilmeals, and cotton lint. Then their foreign demand estimates are discussed. Finally the process by which these individual demand components are aggregated and adjusted for White Area production is presented.

Demand for Feed Grains by Livestock

The demand for feed grains as livestock feed is based on consumer demand for livestock products. From the demand for livestock products, a derived demand for feed grains by each type of livestock is estimated. Nine classes of livestock products are defined for this study. These nine (Table 9) are aggregations of the 13 livestock classes in National and State Livestock-Feed Relationships (53).

Table 9. Livestock categories

New category	Category (or categories) in original source (53)
1) Dairy	1) Milk cows and heifers over two years old 2) Heifers and heifer calves kept for milk
2) Beef	3) Cattle on feed 4) Other beef cattle
3) Hogs	5) Hogs
4) Chickens	6) Hens and pullets 7) Chickens raised for replacement
5) Broilers	8) Broilers
6) Turkeys	9) Turkeys
7) Sheep	10) Stock sheep 11) Sheep and lambs on feed
8) Horses and mules	12) Horses and mules
9) Other livestock	13) Other livestock

Beef, pork, and broiler demands are estimated from Equations 3.1, 3.2 and 3.3, respectively. These equations were developed by Waugh (74) and adapted in (16). The demand estimates for sheep and for turkeys are given in Equations 3.4 and 3.5, respectively, and were developed in (16).

$$Q_1 = 43.7809 - 0.7697 * RP_1 + 0.2786 * RP_2 + 0.1076 * RP_3 + 0.0386 * Y \tag{3.1}$$

$$Q_2 = 90.1111 + 0.2786RP_1 - 0.9612 * RP_2 + 0.0728RP_3 + 0.0032 * Y \tag{3.2}$$

$$Q_3 = 32.0623 + 0.1076 * RP_1 + 0.0728 * RP_2 - 0.4485RP_3 + 0.0023 * Y \tag{3.3}$$

$$Q_4 = e^{5.57087} * RPI_4^{-1.9916} * RPI_1^{0.57397} * Y^{0.36813} * I^{-0.13775} \tag{3.4}$$

$$Q_5 = e^{2.40871} * RPI_5^{-0.43835} * RPI_1^{0.19729} * T^{0.21801} \tag{3.5}$$

where

Q_i is the per capita consumption (in pounds per year) of the i-th livestock product (i = 1,2,3,4,5 for beef, pork, broilers, sheep, and turkeys, respectively);

RP_i is the retail price of commodity i in 1957-59 prices;

Y is per capita disposable consumer income in 1957-59 dollars (64);

e is the base of the natural logarithms;

RPI_i is the retail price index for commodity i (1957-59 = 100); and

T is time in years (T = 1 in 1948).

The demand for beef, Q_1, can be partially satisfied by the slaughter of cull dairy animals. Therefore, the demand for feed grains by beef must be reduced to account for the meat production of dairy animals. Procedures given in Cattle Raising in the United States (48) are used to estimate dairy animal slaughter.

When Equations 3.3, 3.4, and 3.5 are compared with actual 1960-1970 data, they give unsatisfactory results especially at the latter part of the period because of shifts in consumer preferences which had occurred by that time. Therefore, the results of these equations were adjusted to reflect their estimation bias in that period. The estimates of per capita consumption for each of the five livestock classes discussed above are presented in Table 10 along with recent actual data.

Separate demand estimates for livestock products are not calculated for each of the seven model alternatives. The same demand levels are used for Alternatives A and F because their estimated price of feedstuffs is relatively equal. Although the price of feedstuffs does vary among Alternatives B, C, D, and E; separate livestock demands are not estimated for them

Table 10. Estimates of per capita consumption of selected livestock products with 1969-73 averages for comparison

Livestock class	1969-73 average[a]	1972-73 average[a]	Model alternatives		
			A,F	G	B,C,D,E
Beef (lbs.)	115.4	115.5	136.6	135.0	129.7
Pork (lbs.)	66.7	64.5	65.3	64.2	61.0
Broilers (lbs.)	38.9	42.5	40.2	40.2	40.4
Sheep (lbs.)	3.2	3.0	3.2	3.0	2.6
Turkeys (lbs.)	9.1	9.1	8.9	9.0	9.1

[a]Source: (54).

because a primary impact of these situations is differences in input efficiency between the farm-size structures. If livestock demands had been allowed to vary among the four alternatives, comparison of input requirements among them would have been invalid. Therefore, demand requirements are held constant in these four situations.

Under Alternatives A and F, the consumption of beef in 1980 is estimated to increase from recent levels. This increase follows the upward trend in beef consumption occurring throughout the last decade. The consumption of pork and broilers, however, is estimated to stabilize at levels consistent with the 1969-73 period. Feedstuff prices are slightly higher under Alternative G than under Alternatives A or F.

This leads to a slight reduction in beef and pork consumption for this alternative. Because of the increased crop exports associated with Alternative B feedstuff prices are significantly higher for that situation than for Alternatives A or F. The estimated consumption of beef, pork, and sheep decreases sharply under Alternative B as higher feed prices are reflected in higher livestock prices. Part of this decrease is offset by consumption increases for broilers and turkeys. As discussed previously, consumption levels are forced to remain constant for Alternatives B, C, D and E.

The annual demand for eggs and for dairy products is specified to be 290 eggs and 318.5 pounds per person, respectively. These estimates are held constant among the seven alternatives.

National demands for the seven livestock classes cited above are the product of the estimated per capita values and the projected national population 232.0 million people, in 1980. To account for milk consumption by dairy calves, dairy product consumption at the national level is increased by 1.823 billion pounds, the 1967-69 average consumption (42).

The next step is to adjust the national livestock demands for net imports of each product. Net imports (on a per capita basis) are set at their 1969-71 average for each livestock product (51). The per capita estimates are combined with the projected 1980 population to form national net imports. The national demand estimates are adjusted by the estimated net imports to estimate domestic production for each situation.

Now we need a process to transform domestic livestock production to a demand for feed grains. To do this, historic data and the concept of a grain-consuming animal unit are used. One grain-consuming animal unit consumes the same quantity of feed grains no matter what class of livestock is being discussed. Of course, the number of sheep required to form one grain-consuming animal unit varies considerably from the number of broilers required (milk cows are the base livestock class).

To relate livestock demands to feed grain requirements, historic relationships between quantity of output and the number of grain-consuming animal units for each of seven livestock classes are quantified. This relationship is given in Equation 3.6;

$$F_i = GCAU_i/TQ_i \qquad (i = 1,2,\ldots,7) \qquad (3.6)$$

where

F_i is the number of grain consuming animal units per unit of output for the i-th livestock class;

$GCAU_i$ is the average number of grain-consuming animal units of livestock class i fed in the United States in the years 1968-70 (53); and

TQ_i is the average number of units of output of the i-th livestock class produced in the years 1968-70 (51).

TQ_i is analogous to the domestic livestock production estimated previously. Therefore, given the relationship in Equation 3.6 and the estimate of the national production for each livestock class, the number of grain-consuming animal units required can be estimated as in Equation 3.7:

$$EGCAU_i = F_i * ETQ_i \qquad (i = 1,2,\ldots,7) \qquad (3.7)$$

where

$EGCAU_i$ is the estimated number of grain-consuming animal units of the i-th livestock class;

F_i is the output of Equation 3.6 for the i-th livestock class; and

ETQ_i is the estimated national production of the i-th livestock class.

As of yet, two livestock classes have not been discussed; horses and mules, and other livestock. The number of grain-consuming animal units of horses and mules is set at 1.261 million, the 1968-70 average (53). Projection of the demand for feed grains for other livestock does not use the grain-consuming animal unit concept. Instead, other livestocks' feed grains demand is estimated directly by Equation 3.8:[1]

$$\underset{}{FU_9} = \underset{(156.43605)}{2504.4724} + \underset{(11.9108)}{199.99353} * T \qquad R^2 = .932 \qquad (3.8)$$

[1]The notation in Equation 3.8 is used throughout the report; the value in parentheses is the standard error of the variable above it and R^2 is the multiple correlation coefficient of the equation.

where

FU_9 is the number of feed units of feed grains required by other livestock; and

T is defined as before.

For the other eight livestock classes national feed grain demands are derived from Equation 3.9:

$$FU_i = 1.287 * EGCAU_i \qquad (i = 1,2,\ldots,8) \qquad (3.9)$$

where

FU_i is the number of feed units of feed grains required by the i-th livestock class;

1.287 reflects 1960-70 feed conversion trends (53); and

$EGCAU_i$ is defined as before.

Each livestock class's national estimate of feed grains demand must now be distributed to the 31 consuming regions. The historic location of production for each livestock class is used to accomplish this distribution (see Equation 3.10), for every livestock class except other livestock:

$$FU_{i,k} = (GCAU_{i,k}/GCAU_i)*FU_i \qquad (i = 1,2,\ldots,8; \; k = 1,2,\ldots,31) \qquad (3.10)$$

where

$FU_{i,k}$ is the number of feed units of feed grains required in consuming region k by livestock class i;

$GCAU_{i,k}$ is the average number of grain-consuming animal units of livestock class i fed in consuming region k in the years 1968-70 (53), and

FU_i and $GCAU_i$ defined previously.

The other livestock class includes pets, laboratory animals, circus animals, and zoo animals. Data on the historic location of production of these animals are not available so the location of people is used as a proxy in Equation 3.11:

$$FU_{9,k} = (Pop_k/Pop)/FU_9 \quad (k = 1,2,...,31) \tag{3.11}$$

where

$FU_{9,k}$ is the number of feed units of feed grains required by other livestock in the k-th consuming region;

Pop_k is the estimated population of consuming region k in 1980 (66);

Pop is $\sum_{k=1}^{31} Pop_k$; and

FU_9 is defined previously.

For each consuming region, the total feed grains demand by all livestock classes is calculated as the summation of each livestock class's demand in the region as in Equation 3.12:

$$FG_k = \sum_{i=1}^{9} FU_{i,k} \qquad (k = 1,2,\ldots,31) \qquad (3.12)$$

where

FG_k is the feed grain demand (in feed units) by livestock in the k-th consuming region; and

$FU_{i,k}$ is defined previously.

Food and Industrial Demands for Feed Grains

Six separate food and industrial demand categories are specified for feed grains. These categories are corn for cereal, corn for dry processing, corn for wet processing, corn for alcohol, oats for cereal, and barley for malt and food. When a significant historic trend exists for these categories, regression analysis is used to estimate 1980 demands. If no trend exists, the 1966-69 average per capita consumption is used (51). Per capita demand projections for the six feed grain categories are given in Equations 3.13 through 3.18.

$$C_c = \underset{(0.002372)}{0.066847} + \underset{(0.000181)}{0.001867}\, T \qquad R^2 = .842 \qquad (3.13)$$

$$C_{dp} = \underset{(0.011744)}{0.398122} + \underset{(0.000894)}{0.009321}\, T \qquad R^2 = .844 \qquad (3.14)$$

$$C_{wp} = \underset{(0.065991)}{0.237624} + \underset{(0.000034)}{0.000364}\, Y \qquad R^2 = .86 \qquad (3.15)$$

$$C_a = 0.1670 \qquad \text{(1966-69 average)} \qquad (3.16)$$

$O_c = 0.2248$ (1966-69 average) (3.17)

$B_m = 0.5911$ (1966-69 average) (3.18)

where

C_c is the per capita demand for corn in cereal (in bushels);

C_{dp} is the per capita demand for corn for dry processing (in bushels);

C_{wp} is the per capita demand for corn for wet processing (in bushels);

C_a is the per capita demand for corn for alcohol (in bushels);

O_c is the per capita demand for oats for cereal (in bushels);

B_m is the per capita demand for barley in food and malt (in bushels); and

T and Y are defined previously.

Total national demands are calculated by multiplying the per capita estimates just listed times the 1980 estimated population, 232.0 million persons. The national demands for corn and oats for cereal are distributed to the consuming regions based on each regions proportion of the employees in the cereal preparations industry; as given in the Census of Manufacturers (65). The national demand for corn for dry processing is distributed by the proportion of corn mills located within each consuming region; as given in The Northwestern Miller (30). The national demands for corn for wet processing, corn for alcohol, and barley for food and malt are distributed among the consuming regions based on the proportion of employees of each region in the wet corn milling; the distilled spirits, except brandy; and the sum of the malt and malt liquor industries, respectively; as given in the Census of Manufacturers (65).

Each of these regional estimates are converted to a feed unit basis so a total demand for feed grains can be estimated. One feed unit of a commodity is the quantity of that commodity necessary to equal the feed value of one unit of corn grain. The feed value of each commodity in the study (as compared to corn grain) is: wheat, 1.05; oats, 0.90; barley, 0.90; grain sorghum, 0.95; corn, 1.00; cottonseed oilmeal, 1.35; and soybean oilmeal, 1.65 (49).

Demand for Winter and Spring Wheat as Food

The per capita demand for winter and spring wheat for flour and other industrial uses is calculated using Equation 3.19.

$$W = 1.79217 + \underset{(0.7459)}{30.1755} * (1.0/\text{Time}) \qquad (3.19)$$

where

W is the bushels of wheat demanded for flour and other industrial purposes per person and

Time is the number of years after 1929 (Time = 1 in 1930).

The demand for wheat for food is projected to be 2.384 bushels per capita in 1980 using this procedure. The total wheat demand just estimated is then divided into separate demands for winter and spring wheat based on their average production in the years 1968-70 (42). These separate demands are then converted from bushels to pounds of feed units. The national demands for spring and winter wheat for flour and other industrial purposes are distributed to the consuming regions based on the flour milling capacity of each consuming region. These capacities are reported in The Northwestern Miller (30).

Demand for Oilmeals for Crushing

The preliminary demand for soybean oilmeal is estimated in Equation 3.20:

$$S_m = -10{,}570.582 + 503.8572*T + 0.171529*EGCAU \qquad (3.20)$$

where

S_m is thousand tons of feed units of soybean oilmeal;

EGCAU is the total number of grain-consuming animal units fed to the eight livestock classes (equivalent to

$$\sum_{i=1}^{8} EGCAU_i); \text{ and}$$

$EGCAU_i$ and T are defined previously.

This estimated demand is reduced to .9 * S_m because the historic trend of increasing protein levels in livestock rations is expected to level off in the 1970's (21).

The demand for cottonseed oilmeal is set equal to the 1967-69 average domestic disappearance of cottonseed cake and meal, 2411.7 thousand tons of feed units, as reported in U.S. Fats and Oils Statistics (56). The total demand for oilmeals is the sum of the estimated demands for soybean oilmeal and cottonseed oilmeal.

The consuming region demand for soybeans for crushing is based on the location of each soybean crushing plant and its estimated capacity. The proportion of the national demand attributable to each consuming region was that reported by Koo (21). The demand for cottonseed oilmeal is distributed among the consuming regions based on the regional demand for soybean oilmeal. While this does not accurately reflect the regional demand for cottonseed oilmeal, it does preserve the proper location of soybean oilmeal demand.

Domestic Demand for Cotton Lint

Only a national demand for cotton lint is estimated for this study. As discussed in Chapter I, the domestic utilization of cotton lint has declined steadily from 27 pounds per person in 1939 to 18 pounds in 1970. This steady decline is not expected to continue in the future. Therefore, the demand for cotton lint is specified at 17 pounds per person in 1980. This results in a national demand of 3.9 billion pounds or 8.22 million, 480-pound bales. Cotton lint demand is assumed to be inelastic with respect to the supply price of cotton lint.

Exports

Estimates of 1980 export levels under two differing views of the future are incorporated in this study. One view (called trend exports) assumes that future export levels can be determined by the long run trend in exports. Data from 1949 to 1971 are used to project export levels for this situation. Estimates for this future are greater than exports in the late 1960's but would be less than 1972-73 average exports for some commodities. An alternative view of the future (called maximum exports) assumes that American agriculture will operate at full capacity and any production in excess of domestic demand is exported. Estimates for these two situations and recent actual data are presented in Table 11 below.

Table 11. Estimates of 1980 exports with 1969-73 and 1972-73 averages for comparison

	1969-73 average[a]	1972-73 average[a]	Trend exports	Maximum exports
			Model alternatives	
			A,F,G	B,C,D,E
Wheat (mil. bu.)	862.0	1,167.0	800.0	1,000.0
Feed grains (mil. tons)	29.1	38.2	34.7	43.4
Soybeans (mil. bu.)	448.0	477.5	850.0	938.0
Cotton (mil. bales)	3.7	4.4	3.2	4.0

[a]Source: (57).

Estimates of wheat and cotton lint exports for the trend export level are lower than for either of the recent periods presented, reflecting the very strong demand for these two commodities in the last two years. Feed grain exports under the trend level assumption are greater than 1969-73 average exports but less than the 1972-73 average. This figure suggests a strong future demand for feed grains but not quite as strong as in 1972-73. Soybean exports for this case are much greater than for either recent period. This estimate is greatly affected by the threefold increase in soybean exports which occurred during the 1960's.

To determine exports for the maximum level case, estimates for the trend level case are increased by an equal percentage for each of the four commodities. The percentage increase which just exhausts the land base of the model is then chosen to approximate full capacity production. For all of the commodities, export estimates for the maximum level case are 25 percent greater than their trend export estimates.

Cotton lint exports are added to the domestic demand estimate to form a national demand for cotton lint. For the commodities with regional demands, the national export estimates had to be distributed to the consuming regions. The total wheat demand was first split into a separate export demand for winter and spring wheat based on their historic production proportions (42). Exports of winter and spring wheat as grain are then distributed to the consuming regions based on the historic location of exports of each of them as separate commodities between December 1969 and November 1972 (44,45,46,47). Exports of feed grains and soybeans as grain are distributed to the consuming regions based on the relative amounts of each of these commodities exported from each port during that same time period (44,45,46,47).

A significant proportion of spring wheat, winter wheat and soybeans are exported as processed products---not as grain (11.6 percent of winter and spring wheat exports and 30 percent of soybeans exports (51)). The export demand for these commodities as processed products is distributed to the consuming regions based on the location of the domestic demand for these products.

Total Demands

The separate sources of demand for each of the commodities in the model must be summed to form total demands for them. Equations 3.21 through 3.25 describe this summation process.

$$D_{sw,k} = SW_k + EG_{sw,k} + EP_{sw,k} \quad (k = 1,2,\ldots,31) \tag{3.21}$$

$$D_{ww,k} = WW_k + EG_{ww,k} + EP_{ww,k} \quad (k = 1,2,\ldots,31) \tag{3.22}$$

$$D_{fg,k} = FG_k + C_{c,k} + C_{dp,k} + C_{wp,k} + C_{a,k} + O_{c,k} + B_{m,k} + EG_{fg,k} \quad (k = 1,2,\ldots,31) \tag{3.23}$$

$$D_{om,k} = C_{om,k} + EG_{s,k} + EP_{s,k} \quad (k = 1,2,\ldots,31) \tag{3.24}$$

$$D_{cl} = U_{cl} + E_{cl} \tag{3.25}$$

where

$D_{j,k}$ is the total demand for the j-th commodity in the k-th consuming region (j = sw, ww, fg, and om for spring wheat, winter wheat, feed grains, and oilmeals, respectively);

D_{cl} is the total national demand for cotton lint;

SW_k is the domestic demand for spring wheat for flour and for industrial purposes in the k-th consuming region;

WW_k is the domestic demand for winter wheat for flour and for industrial purposes in the k-th consuming region;

$EG_{l,k}$ is the export demand for the l-th commodity as grain in the k-th consuming region (l = sw, ww, fg and s for spring wheat, winter wheat, feed grins, and soybeans, respectively);

$EP_{n,k}$ is the export demand for the n-th commodity as a processed product in the k-th consuming region (n = sw, ww, and s for spring wheat, winter wheat, and soybeans, respectively);

$C_{om,k}$ is the domestic crushing demand for oilmeals in the k-th consuming region;

U_{cl} is the national domestic demand for cotton lint;

E_{cl} is the national export demand for cotton lint;

$C_{c,k}$ is the domestic demand for corn in cereals in the k-th consuming region;

$C_{dp,k}$ is the domestic demand for corn for dry processing in the k-th consuming region;

$C_{wp,k}$ is the domestic demand for corn for wet processing in the k-th consuming region;

$C_{a,k}$ is the domestic demand for corn for alcohol in the k-th consuming region;

$O_{c,k}$ is the domestic demand for oats for cereal in the k-th consuming region;

FG_k is the demand for feed grains as livestock feed in the k-th consuming region; and

$B_{m,k}$ is the domestic demand for barley for malt and other uses in the k-th consuming region.

Adjust Total Demand for White Area Production

Not all of the national production of the five commodities is located in the 150 rural areas defined for the programming model. In 1969, production outside of these rural areas was 364, 1,250 and 4,790 thousand tons of feed units of soybeans, wheat, and feed grains, respectively, and 104 thousand bales of cotton lint (71). These quantities were 1.2, 3.2, 3.0, and 1.0 percent of the national production of soybeans, wheat, feed grains, and cotton, respectively, in that year (71).

The demand estimates for 1980 are reduced to account for production in the White Areas. Production from these areas is assumed to be equal to 1969 production levels. Production in each White Area reduces commodity demands in the consuming region in which it is located. If this procedure results in a negative demand for any consuming region, this excess demand is allocated to an adjacent consuming region.

CHAPTER IV. PROGRAMMING MODEL COEFFICIENTS

A large number of coefficients had to be estimated to formulate the programming model developed for this study. The demand quantities discussed in Chapter III form a portion of the right-hand side restraints of the model. Derivation of the remainder of the model coefficients are discussed in this chapter. Estimation of these coefficients drew heavily on previous work done at Iowa State University (Skold (37), Whittlesey (76), Heady and Mayer (13), and Eyvindson (6) and work being done at the same time this model was being developed (Stoecker (39), Nicol (29), and Koo (21)).

Crop Yields

A unique crop yield for each crop production activity defined in the models 150 rural areas had to be estimated for 1980. To be consistent with Eyvindson's data (6), his assumption that a single yield is relevant for each of the farm-size structures is adopted here. The models yields are derived from Stoecker's state yield projections (39). These state yields are based on time series data from the years 1949 to 1969 and incorporate trends in the percentage of total acreage fertilized, yield on fertilized land, rate of application of fertilizer per acre, and yields on unfertilized land. Separate state yields are developed for corn grain, sorghum grain, barley, oats, wheat, soybeans, and cotton lint. For the 17 Western states, separate irrigated and dryland yields are projected for the crops relevant in those states.

For each crop, the yield function is of a form derivable from the Spillman production function (12). The form of the function used is given in Equation 4.1:

$$Y_t^i = Y_{o,t}^i + A^i(1 - .8^{X_t^i}) * P_t^i \qquad (4.1)$$

where

Y_t^i is the average per acre yield of crop i estimated for year t;

$Y_{o,t}^i$ is the average yield per acre of crop i on unfertilized land estimated for year t, which is developed from a linear trend function;

.8 is the ratio of successive marginal products, which is set to equal .8 following the suggestion of Ibach and Adams (19);

A^i is the maximum response obtainable from fertilization for crop i;

X_t^i is the estimated number of units of fertilizer applied per acre for crop i in year t;

P_t^i is the proportion of the acreage of crop i receiving fertilizer in year t, which is developed from a linear trend function; and

t is years after 1949.

For each crop a unit of fertilizer refers to a specific mixture of nitrogen, phosphorus and potassium.

X_t^i as defined above is estimated from Equation 4.2:

$$X_t^i = P_{o,t}^i * \left[(LN\left\{P_x^i \;/\; P_c^i\right\} - LN(A^i) - (LN(-LN.8))/LN.8 \right] \qquad (4.2)$$

where

LN is the natural log of base e;

P_x^i is the price of a unit of fertilizer for crop i;

P_c^i is the price of a unit of crop i; and

$P_{o,t}^i$ is a linear estimate of the proportion of the optimum rate of fertilizer applied to crop i in year t.

The portion of Equation 4.2 enclosed in brackets represents an estimate of the optimum quantity of fertilizer for the i-th crop, obtained by solving the marginal conditions of a profit maximizing system.

Equation 4.1 is used to estimate separate dryland and irrigated yields for the 17 Western states. These separate yields are aggregated to a state average yield based on the proportion of the total acres irrigated in these states. This data is from Eyvindson (6).

Next the state average yields for each of the seven crops must be disaggregated to the 150 rural areas of the model.

Data which relate 1970 estimated state yields to a 1970 estimated yield in each rural area are available from Heady and Mayer (13). These same relationships are used to distribute the newly estimated state yields to the rural areas.

The yields of corn grain, sorghum grain, barley and oats are now aggregated to a yield for feed grains for 1980. Feed grain rotation weights based on 1964 actual data (70) are used to calculate a single feed grains yield in feed units from the four separate crop yields in each rural area.

As noted in Chapter III, the demand for each of the commodities as seed is accounted for by reducing each commodities yield for the quantity of seed required per acre. State seeding rates (42) are used to reduce the yield of each rural area to reflect the demand for each commodity as seed.

In this programming model, spring and winter wheat are treated as separate commodities and the demand for all wheat is the sum of their individual demands. In each rural area, then, the per acre yield of all wheat (which is the form wheat yields are in at this stage) must be subdivided to form a yield of spring wheat and a yield of winter wheat. The historic proportion of spring and winter wheat grown in each rural area is used to estimate this subdivision (71). The estimated yield of all wheat in each rural area is multiplied times the proportion of spring wheat and the proportion of winter wheat grown in each rural area. This forces each rural area in the model to grow the same proportion of spring and winter wheat as it did in the past.

The estimated yields of winter and spring wheat, feed grains, soybeans, and cotton lint are presented in Table 12. All yields are in tons of feed units per acre except for cotton lint which is in 480-pound bales per acre. Cottonseed oilmeal yields are directly related to cotton lint yields. It was estimated that each 480-pound bale of cotton lint will yield .26 of a ton of feed units of oilmeal (42).

Crop Production Costs

For each farming structure, cost coefficients had to be estimated for each of the 472 crop production activities in the model. Only 472 production activities are specified, as some rural areas do not produce all of the model commodities. Also only one wheat production activity is specified in each rural area. This activity may contain a yield coefficient for spring or winter wheat or both. These cost coefficients, 1888 in all, reflect the cost of producing a harvested acre of each of the four crop commodities for a particular farming structure in a particular rural area. Production costs include expenditures for machinery and equipment, fertilizer, pesticides, irrigation water, seed, miscellaneous items, and labor. Much of the data on production costs has been derived and updated from Eyvindson's cost data (6). The coefficients used to

Table 12. Yield coefficients for each crop commodity in each of the 150 rural areas of the model

Rural area	All wheat	Winter wheat	Spring wheat	Feed grains	Soybeans	Cotton lint
	(Tons of feed units)					(Bales)
1	1.17759	1.17759	---	1.59844	0.67567	---
2	1.16859	1.16859	---	2.09762	1.27288	---
3	1.16067	1.16067	---	1.99768	1.26797	---
4	1.26384	1.26384	---	2.24575	1.32144	---
5	1.41082	1.41082	---	1.90929	0.98657	---
6	1.29099	1.29099	---	2.07260	0.99069	0.67538
7	1.53947	1.53947	---	2.05665	1.23905	0.90942
8	1.40606	1.40606	---	1.39323	0.95649	0.82572
9	1.35880	1.35880	---	1.44080	0.95649	0.86495
10	1.53947	1.53947	---	1.70923	1.13108	0.79345
11	1.26420	1.26420	---	1.51790	1.44889	0.81355
12	1.13664	1.13664	---	1.28359	0.88221	0.53155
13	0.76360	0.76360	---	1.48742	0.89075	0.77371
14	1.32533	1.32533	---	1.45931	1.04698	0.92566
15	1.16432	1.16432	---	1.19316	0.86547	0.67712
16	1.25318	1.25318	---	1.29538	0.82670	0.88239
17	1.12701	1.12701	---	1.22356	1.26507	0.79774
18	1.10927	1.10927	---	1.46817	1.40782	0.82888
19	1.18387	1.18387	---	1.22868	0.92454	1.21737
20	0.90385	0.90385	---	1.25286	1.19963	1.22132
21	---	---	---	0.915100	1.98734	0.92869
22	0.96314	0.96314	---	0.79797	0.65570	0.6990
23	0.92110	0.92110	---	0.89343	0.51945	0.73986
24	1.21681	1.21681	---	1.12944	0.96780	0.88185
25	1.13347	1.13347	---	1.06771	0.98206	1.01703
26	1.14787	1.14787	---	1.28687	1.19145	0.96947
27	0.71836	0.71836	---	1.19696	1.01230	1.14989
28	1.11857	1.11857	---	1.70547	0.95072	0.98801

Table 12 (Continued)

Rural area	All wheat	Winter wheat	Spring wheat	Feed grains	Soybeans	Cotton lint
		(Tons of feed units)				(Bales)
29	1.34256	1.34256	---	1.74495	1.11395	1.29127
30	1.03447	1.30447	---	1.22703	1.02453	1.33856
31	0.80089	0.80089	---	1.33900	1.01868	1.23689
32	1.33766	1.33766	---	2.04966	1.19531	1.08804
33	1.25772	1.25772	---	1.78773	1.09040	---
34	1.19545	1.19545	---	1.71616	1.24209	---
35	1.10116	1.10116	---	2.05883	1.19738	---
36	0.91970	0.91970	---	2.33312	1.02448	---
37	1.15248	1.15248	---	2.06597	0.99838	---
38	1.30552	1.30552	---	2.02739	1.11397	---
39	1.26565	1.26565	---	2.49813	1.20221	---
40	1.36336	1.36336	---	2.83928	1.26525	---
41	1.23065	1.23065	---	2.04846	1.16634	---
42	1.23208	1.23208	---	2.60885	1.06637	---
43	1.53655	1.53655	---	3.01717	1.31463	---
44	1.61058	1.61058	---	2.75596	1.30796	---
45	1.34396	1.34396	---	2.05274	1.01975	---
46	1.44194	1.44194	---	1.85386	0.94510	---
47	1.01195	0.05262	0.95933	1.15688	0.85875	---
48	1.33211	1.04837	0.28374	2.01846	1.14144	---
49	1.18396	0.49134	0.69262	2.25930	0.99054	---
50	1.46719	1.46719	---	2.96214	1.49155	---
51	1.55380	1.55380	---	3.15546	1.54714	---
52	1.19598	1.19598	---	2.36199	1.08017	---
53	1.21728	1.21728	---	2.02312	1.09685	---
54	1.28402	1.28402	---	2.26248	1.15244	---
55	1.45725	1.45725	---	2.87126	1.44151	---
56	0.92000	0.92000	---	1.00022	1.05919	0.96949

Table 12 (Continued)

Rural area	All wheat	Winter wheat	Spring wheat	Feed grains	Soybeans	Cotton lint
		(Tons of feed units)				(Bales)
57	0.59562	0.59562	---	1.07919	1.20334	1.29274
58	0.88291	0.88291	---	1.08183	1.16492	0.85057
59	0.80556	0.80556	---	1.09700	0.81636	0.99993
60	1.12849	1.12849	---	1.14500	1.06875	1.18713
61	1.11917	1.11917	---	1.14201	0.97781	0.95017
62	1.08652	1.08652	---	1.08977	0.92365	0.84473
63	1.28524	1.28524	---	2.07885	1.12167	1.17230
64	1.16540	1.16540	---	1.68411	0.79271	---
65	1.31644	1.31644	---	2.19817	1.25055	---
66	1.14664	1.14664	---	2.51975	1.28340	---
67	1.08390	1.08390	---	2.22551	1.22005	---
68	1.49999	1.49999	---	2.81467	1.36928	---
69	1.34892	1.34892	---	2.78694	1.49458	---
70	1.43981	1.43981	---	2.33293	1.19893	---
71	1.52175	1.52175	---	2.91136	1.42700	---
72	1.02757	1.02757	---	2.45087	1.40025	---
73	1.28723	0.07723	1.21000	2.22177	1.04170	---
74	1.42575	0.13830	1.28745	2.64256	1.22652	---
75	1.20952	0.11732	1.09220	2.23685	1.06932	---
76	1.05464	0.43240	0.62224	1.43528		---
77	1.01470	0.02537	0.98933	1.94837	0.93017	---
78	1.01911	0.01421	1.0049	1.16168	0.72305	---
79	1.17011	0.00468	1.16543	0.98904	0.76235	---
80	1.23375	0.00370	1.23005	1.14828	0.67339	---
81	0.97327	0.00195	0.97132	0.92909	0.48855	---
82	0.91506	0.00275	0.91231	0.79798	---	---
83	0.79197	0.02455	0.76742	0.77329	---	---
84	0.79865	0.00080	0.79785	1.22773	0.76581	---
85	0.87230	0.62893	0.24337	0.67106	0.55877	---

Table 12 (Continued)

Rural area	All wheat	Winter wheat	Spring wheat	Feed grains	Soybeans	Cotton lint
		(Tons of feed units)				(Bales)
86	0.76389	0.09931	0.66458	0.89210	0.55107	---
87	0.82795	0.00745	0.82050	1.29342	0.76745	---
88	1.00127	0.86910	0.13217	1.02628	0.58575	---
89	0.86656	0.37782	0.48874	1.67846	0.99865	---
90	0.96845	0.96845	---	2.74753	1.22180	---
91	1.01850	1.01850	---	0.98540	---	---
92	1.08694	1.08694	---	1.78237	---	---
93	0.89592	0.89592	---	3.04584	1.41120	---
94	0.95210	0.95210	---	2.20508	1.23380	---
95	0.98683	0.98683	---	3.08984	1.17511	---
96	1.25150	1.25150	---	2.50584	1.11856	---
97	1.24163	1.24153	---	2.15616	1.05172	---
98	1.23655	1.23655	---	1.78652	0.85020	---
99	1.24851	1.24851	---	1.68790	0.89609	---
100	1.10996	1.10996	---	1.73827	0.81030	---
101	1.21562	1.21562	---	1.43727	0.61277	---
102	1.14784	1.14784	---	1.43520	0.74645	---
103	0.90762	0.90762	---	1.35903	0.76440	---
104	0.85080	0.87080	---	1.72113	0.89909	---
105	1.15919	1.15919	---	1.25465	0.55225	0.79453
106	1.02679	1.02679	---	1.14584	0.54656	0.87290
107	0.81013	0.81013	---	1.07814	---	0.95210
108	0.98420	0.98420	---	1.10751	0.76966	0.88624
109	1.05086	1.05086	---	1.28110	1.05302	0.50773
110	0.85272	0.85272	---	1.20634	1.40233	0.50606
111	0.94253	0.94253	---	1.12279	0.82340	0.89624
112	0.99744	0.99744	---	2.50512	1.32666	1.60618
113	0.80179	0.80179	---	0.79670	---	0.66701

Table 12 (Continued)

Rural area	All wheat	Winter wheat	Spring wheat	Feed grains	Soybeans	Cotton lint
		(Tons of feed units)				(Bales)
114	0.86192	0.86192	---	1.26541	0.93933	0.93935
115	0.76141	0.76141	---	0.60983	1.26190	0.46250
116	0.69410	0.69410	---	0.85837	---	0.49554
117	1.02436	1.02436	---	1.30586	0.65753	0.62060
118	0.78833	0.78833	---	0.81279	0.73667	0.37283
119	---	---	---	1.33257	1.10841	0.72836
120	---	---	---	0.88885	0.59103	0.70311
121	---	---	---	1.35335	---	0.71027
122	0.87628	0.87628	---	0.99184	---	0.68668
123	---	---	---	1.70766	---	0.75983
124	0.65999	0.65999	---	1.81703	---	0.97692
125	---	---	---	1.89070	---	1.09019
126	---	0.69410	---	1.58567	---	0.66465
127	---	---	---	2.15595	1.43818	1.78473
128	0.41050	0.41050	---	0.93951	---	0.70241
129	0.68030	0.68030	---	1.44715	---	0.85372
130	1.02704	1.02396	0.00308	1.55422	---	1.25527
131	0.65044	0.64979	0.00065	0.94767	---	---
132	0.64104	0.63912	0.00192	1.70138	---	---
133	0.80463	0.80302	0.00161	0.96294	---	---
134	0.95491	0.94632	0.00859	2.50665	---	---
135	0.83974	0.80195	0.03779	0.90989	---	---
136	0.75204	0.58659	0.16545	0.66949	---	---
137	0.72502	0.21098	0.51404	0.92129	---	---
138	1.18615	0.95722	0.22893	0.90724	---	---
139	1.06276	0.97136	0.09140	1.01854	---	---
140	1.27797	0.73867	0.53930	1.20826	---	---

Table 12 (Continued)

Rural area	All wheat	Winter wheat	Spring wheat	Feed grains	Soybeans	Cotton lint
		(Tons of feed units)				(Bales)
141	0.95977	0.69967	0.26010	1.43423	---	---
142	1.99271	1.99271	---	1.68664	---	2.06956
143	2.48330	2.483301	---	0.83532	---	2.53018
144	1.30329	1.30329	---	0.85612	---	2.01920
145	1.80961	1.80961	---	0.78413	---	---
146	1.63858	1.61400	0.02458	1.30791	---	---
147	1.62673	1.57955	0.04718	1.29590	---	---
148	1.34432	1.31340	0.03092	1.05876	---	---
149	1.19880	1.05015	0.14865	1.06513	---	---
150	1.08101	0.86913	0.21188	1.39303	---	---

update that data to a 1980 basis are from Stoecker (39). Fertilizer costs for 1980 are based on the yield estimates discussed in the previous section.

Because of data limitations, not all components of production cost vary among the farm-size structures. Eyvindson specified that expenditures for miscellaneous items, pesticides, seed, and irrigation water remain constant among the farm-size structures. Since yields aren't allowed to vary by farm size, fertilizer costs also do not change. Land is a fixed resource in the model and receives any residual return based on the level of its usage in each rural area. Therefore, land rent is not included in the cost coefficients.

The cost of using a machine includes depreciation, shelter, insurance, taxes, repairs, lubrication, and fuel and oil. For the four crop activities, Eyvindson defined a sequence of field operations for each machine in each farm-size structure. This sequence of operations was weighted by the cost of using each machine to reflect machinery costs per acre. A different sequence was specified for irrigated and dryland production and a total cost for each activity was computed as the weighted average of irrigated and dryland machinery costs.

Per acre pesticide costs for the relevant crops were obtained from unpublished state data collected for the 1964 Pesticide Uses Survey by the USDA; as developed by Eyvindson (6). State pesticide costs were then assumed to be applicable for each of the areas within it.

Miscellaneous costs are the summation of expenditures for lime, ginning cotton, shelling corn grain, and drying corn grain and sorghum grain (6). Drying costs were not estimated for crops other than corn grain and sorghum grain as only a small portion of the other crops are dried.

Labor requirements for each crop and each farm-size structure were calculated by Eyvindson. These labor requirements include estimates of the direct labor required to produce the crops as well as indirect labor needs for tasks such as the repair and service of equipment. Direct labor requirements are the quantity of labor needed to operate the machinery used in the sequence of field operations discussed previously. Separate labor requirements were estimated for irrigated and dryland production and then summed to form a projected per acre labor requirement. State estimates of wage rates for hired labor in 1964 were then applied to these labor requirements to determine a per acre labor cost (39). The use of hired labor wage rates assumes that farm owners will charge each crop activity for their own labor at a wage equal to that of hired labor.

The data just discussed represent cross-sectional data for each rural area in the model. Stoecker developed ratios based on time series data which project changes in capital and labor usage to the year 1980 (39). These ratios are specific to each crop in each of the ten farm production regions of the nation. The machinery and equipment cost coefficients for each farm-size alternative, as well as the pesticide and miscellaneous costs discussed above, were summed and weighted by the change in capital usage coefficients to form a 1980 cost estimate. Similarly the labor cost coefficient for each farm-size structure was updated by Stoecker's change in labor usage ratios.

The coefficients for the cost categories just developed as well as irrigation costs obtained from Stoecker (39) relate to Eyvindson's 157 producing areas. Fortunately, these areas correspond very closely to the 150 rural areas of this model. In 123 of the rural areas, an Eyvindson producing area is identical to one of the model areas. In the 27 rural areas where differences exist, adjustments to the cost data were needed. In these instances, two or more rural areas were contained in one Eyvindson producing area. The new costs in these rural areas were forced to have the same relation to each other as they had in the Heady and Mayer study (13), but were based on the 1980 coefficients just developed. This procedure maintained the relative cost structure of the 150 rural areas while incorporating the 1980 estimated data.

Each of these cost components (machinery and equipment, labor, pesticides, and miscellaneous costs) are summed to form a cost coefficient for each crop for each farm-size structure by the 150 rural areas. These costs are adjusted by the change in prices paid by farmers to account for inflation from 1965 to 1972. They are now in terms of 1980 physical quantities reported in 1972 prices. To these costs we now must add expenditures for fertilizer and the nonfarm portion of seed costs.

Associated with each crop yield in each rural area is a unique level of fertilization. Fertilizer usage on a state basis is determined in Equation 4.2, which then is used in Equation 4.1 to estimate the state yield for each crop. In Equation 4.2, X_t^i refers to a unit of fertilizer containing a different mixture of nitrogen, phosphorus, and potassium for each crop in each state. To form state fertilizer costs, the units of fertilizer required were multiplied by 70-72 average prices (29). These state fertilizer costs (dryland and irrigated) were then distributed to each of the rural areas in the same manner as the state yields were (described in the previous section).

To reflect seed demands, seed requirements were deducted from each crop yield. Therefore, the farm value of that seed requirement could not be added to production costs. However, nonfarm costs for seed are significant for some crops and in those cases are included in the cost of production. No off-farm seed costs are estimated for barley, oats, and cottonseed. Seed for corn grain and sorghum grain are assumed to be entirely purchased from off-farm sources. The proportion of soybeans and wheat seed purchased was calculated as in Equation 4.3:

$$PS_i = 1 - [QSF_i/QS_i] \quad (i = 1,2) \qquad (4.3)$$

where

PS_i is the proportion of seed purchased for the i-th crop in 1970 (i = 1,2 for wheat and soybeans, respectively);

QSF_i is the quantity of the i-th crop used for seed on farms where grown in 1970 (42); and

QS_i is the quantity of the i-th crop used for seed in 1970 (42).

The nonfarm price of seed was calculated as the difference between the price of high quality seed and the season average farm price for the four crops. (All prices were obtained from the 1972 Agricultural Statistics (42) except for the price of high quality grain sorghum seed which was taken from Selected U.S. Crop Budgets (55)). For each crop, the nonfarm seed price was multiplied times the proportion of seed purchased to determine nonfarm seed cost per bushel. This national cost was multiplied times the seeding rates specified for each of the 150 rural areas to determine per acre nonfarm seed costs.

For each farm-size structure in each rural area, the cost components of each crop (machinery and equipment, pesticide, fertilizer, irrigation water, labor, seed, and miscellaneous items) were summed to form a total cost. Each total cost was increased by 6 percent to account for interest charges and is presented in Table 13.

Table 13. Costs of production for each farm-size structure in each of the rural areas of the model

Rural area	Crop	Typical-farm structure	Small-farm structure	Medium-farm structure	Large-farm structure
		(1972 dollars)			
1	Wheat	65.89	76.33	65.39	54.64
1	Feedgrains	76.19	86.93	76.94	63.59
1	Soybeans	87.99	96.72	86.59	66.65
1	Cotton	---	---	---	---
2	Wheat	72.99	79.58	71.57	63.71
2	Feedgrains	116.23	129.15	117.85	95.60
2	Soybeans	96.54	112.40	97.55	69.39
2	Cotton	---	---	---	---
3	Wheat	73.20	82.50	72.44	66.10
3	Feedgrains	109.35	133.61	113.55	91.60
3	Soybeans	68.64	84.03	68.59	57.46
3	Cotton	---	---	---	---
4	Wheat	78.67	88.36	82.37	61.27
4	Feedgrains	109.61	129.88	113.66	91.98
4	Soybeans	68.03	85.53	69.97	54.88
4	Cotton	---	---	---	---
5	Wheat	95.52	103.56	94.16	73.47
5	Feedgrains	117.48	133.90	112.82	86.20
5	Soybeans	63.40	84.58	59.66	42.64
5	Cotton	---	---	---	---
6	Wheat	91.18	95.52	89.35	84.89
6	Feedgrains	114.55	121.41	117.47	88.45
6	Soybeans	62.71	73.73	62.96	44.62
6	Cotton	121.97	132.24	124.53	108.75
7	Wheat	102.18	106.67	100.32	95.82
7	Feedgrains	141.18	147.71	143.94	116.35
7	Soybeans	70.60	81.32	70.84	53.00

Table 13 (Continued)

Rural area	Crop	Typical-farm structure	Small-farm structure	Medium-farm structure	Large-farm structure
			(1972 dollars)		
7	Cotton	186.20	204.60	190.81	116.52
8	Wheat	108.90	113.49	109.03	91.19
8	Feedgrains	125.91	142.86	114.57	102.07
8	Soybeans	77.58	98.17	71.43	60.74
8	Cotton	188.78	197.05	155.35	130.08
9	Wheat	100.24	104.11	98.93	81.84
9	Feedgrains	112.20	118.51	108.22	91.20
9	Soybeans	74.28	85.88	74.31	54.37
9	Cotton	183.03	188.96	172.08	156.13
10	Wheat	101.08	102.34	99.36	91.95
10	Feedgrains	129.61	133.04	127.63	109.27
10	Soybeans	70.80	75.66	71.00	59.15
10	Cotton	173.04	181.37	173.57	155.32
11	Wheat	96.01	102.23	97.57	91.08
11	Feedgrains	115.51	123.05	117.52	94.92
11	Soybeans	63.58	72.53	63.83	55.32
11	Cotton	262.99	289.20	274.77	255.46
12	Wheat	90.28	98.79	91.25	81.65
12	Feedgrains	107.97	116.30	102.62	89.19
12	Soybeans	55.25	63.37	57.39	48.17
12	Cotton	223.94	244.01	223.31	221.80
13	Wheat	76.99	85.69	77.98	68.15
13	Feedgrains	98.43	106.43	93.29	80.39
13	Soybeans	63.95	72.38	66.17	56.60
13	Cotton	265.25	276.76	251.81	249.98
14	Wheat	82.22	97.38	80.85	64.17
14	Feedgrains	97.81	118.57	92.91	75.46

Table 13 (Continued)

Rural area	Crop	Typical-farm structure	Small-farm structure	Medium-farm structure	Large-farm structure
			(1972 dollars)		
14	Soybeans	64.39	85.59	68.19	52.98
14	Cotton	229.73	263.74	240.73	199.61
15	Wheat	87.46	102.29	95.90	69.81
15	Feedgrains	100.46	120.80	95.66	78.57
15	Soybeans	54.16	74.61	57.84	43.15
15	Cotton	245.63	279.48	256.56	215.65
16	Wheat	101.57	111.85	95.94	77.49
16	Feedgrains	98.82	105.90	95.27	79.97
16	Soybeans	58.03	73.01	70.00	52.08
16	Cotton	204.12	224.83	198.50	178.67
17	Wheat	91.12	102.65	99.04	76.22
17	Feedgrains	94.74	105.51	99.95	79.46
17	Soybeans	66.79	82.07	70.22	52.51
17	Cotton	267.91	318.25	281.97	201.71
18	Wheat	105.04	125.80	112.65	90.43
18	Feedgrains	104.10	127.49	106.19	81.84
18	Soybeans	87.96	130.62	94.97	68.72
18	Cotton	287.29	302.42	253.81	212.14
19	Wheat	78.43	95.52	80.27	68.88
19	Feedgrains	83.57	96.53	77.22	68.44
19	Soybeans	56.45	68.65	56.53	44.67
19	Cotton	197.46	214.29	175.87	165.97
20	Wheat	68.58	85.12	70.29	59.36
20	Feedgrains	87.57	102.04	84.04	57.94
20	Soybeans	57.13	75.06	55.72	44.10
20	Cotton	180.07	221.69	182.67	171.86
21	Wheat	--	--	--	--

Table 13 (Continued)

Rural area	Crop	Typical-farm structure	Small-farm structure	Medium-farm structure	Large-farm structure
			(1972 dollars)		
21	Feedgrains	82.80	96.13	71.62	62.90
21	Soybeans	56.70	70.87	53.92	49.81
21	Cotton	243.22	259.22	236.21	195.09
22	Wheat	76.79	80.57	75.70	68.64
22	Feedgrains	87.71	101.39	82.67	64.44
22	Soybeans	59.70	73.52	48.95	48.64
22	Cotton	222.91	214.31	238.36	179.18
23	Wheat	82.64	93.12	83.84	71.37
23	Feedgrains	91.78	104.90	91.31	71.80
23	Soybeans	55.58	66.41	59.13	46.68
23	Cotton	243.79	234.82	248.10	207.72
24	Wheat	85.18	95.16	86.31	74.44
24	Feedgrains	85.54	96.96	85.13	68.13
24	Soybeans	66.54	77.42	70.10	57.59
24	Cotton	249.45	240.50	253.77	213.39
25	Wheat	79.23	93.69	77.29	70.13
25	Feedgrains	87.68	102.79	79.75	71.39
25	Soybeans	55.06	70.90	53.64	45.04
25	Cotton	225.90	217.30	241.35	182.17
26	Wheat	79.88	94.12	77.97	70.90
26	Feedgrains	88.46	102.73	80.97	73.07
26	Soybeans	66.74	82.61	65.32	56.71
26	Cotton	230.22	221.62	245.66	186.49
27	Wheat	51.64	55.68	52.92	49.79
27	Feedgrains	100.21	111.62	99.94	68.86
27	Soybeans	46.66	61.05	54.32	40.64
27	Cotton	222.45	205.54	233.94	156.14

Table 13 (Continued)

Rural area	Crop	Typical-farm structure	Small-farm structure	Medium-farm structure	Large-farm structure
			(1972 dollars)		
28	Wheat	76.03	77.87	73.83	71.37
28	Feedgrains	138.65	147.57	137.72	117.78
28	Soybeans	72.36	82.77	73.46	60.73
28	Cotton	170.43	195.28	174.47	159.31
29	Wheat	75.46	80.51	76.07	66.93
29	Feedgrains	133.79	141.04	128.39	119.53
29	Soybeans	65.68	80.76	62.53	57.19
29	Cotton	166.25	258.05	190.73	125.45
30	Wheat	50.95	55.19	51.64	48.88
30	Feedgrains	93.94	105.40	90.59	79.18
30	Soybeans	58.06	73.52	56.33	53.65
30	Cotton	169.77	174.78	217.88	166.18
31	Wheat	46.49	55.85	48.73	42.50
31	Feedgrains	75.09	82.38	71.34	62.44
31	Soybeans	58.03	74.27	62.96	50.76
31	Cotton	220.40	240.16	210.08	155.78
32	Wheat	65.57	73.34	64.31	60.23
32	Feedgrains	89.78	96.95	89.05	79.57
32	Soybeans	65.33	75.09	67.90	51.35
32	Cotton	157.65	168.74	156.26	116.55
33	Wheat	87.33	93.45	86.14	79.07
33	Feedgrains	141.16	147.43	138.94	118.06
33	Soybeans	81.56	90.68	83.16	64.42
33	Cotton	---	---	---	---
34	Wheat	76.52	84.78	73.54	70.10
34	Feedgrains	103.42	110.34	99.99	81.74
34	Soybeans	73.47	82.31	71.36	63.00

Table 13 (Continued)

Rural area	Crop	Typical-farm structure	Small-farm structure	Medium-farm structure	Large-farm structure
		(1972 dollars)			
34	Cotton	159.82	172.93	160.28	119.48
35	Wheat	88.80	96.19	91.27	68.27
35	Feedgrains	112.31	121.71	113.93	92.85
35	Soybeans	103.98	125.31	105.37	65.74
35	Cotton	---	---	---	---
36	Wheat	55.19	64.60	52.75	46.33
36	Feedgrains	93.40	107.49	92.34	76.24
36	Soybeans	74.65	88.19	71.42	57.42
36	Cotton	---	---	---	---
37	Wheat	55.44	63.01	54.12	48.70
37	Feedgrains	87.42	102.38	84.86	75.59
37	Soybeans	77.75	93.53	73.97	61.21
37	Cotton	---	---	---	---
38	Wheat	58.53	66.01	57.72	50.46
38	Feedgrains	84.19	98.75	81.67	71.92
38	Soybeans	76.20	95.20	70.88	56.30
38	Cotton	---	---	---	---
39	Wheat	49.55	55.70	48.17	44.46
39	Feedgrains	76.49	89.14	74.92	62.46
39	Soybeans	59.18	72.31	54.92	46.61
39	Cotton	---	---	---	---
40	Wheat	70.04	78.41	68.07	62.60
40	Feedgrains	112.11	123.87	111.84	94.57
40	Soybeans	67.76	81.46	64.19	52.00
40	Cotton	---	---	---	---
41	Wheat	70.83	86.11	66.19	58.67
41	Feedgrains	107.33	118.95	99.05	83.11

Table 13 (Continued)

Rural area	Crop	Typical-farm structure	Small-farm structure	Medium-farm structure	Large-farm structure
			(1972 dollars)		
41	Soybeans	63.10	80.61	59.19	44.27
41	Cotton	---	---	---	---
42	Wheat	61.69	70.02	60.77	56.98
42	Feedgrains	96.57	115.99	93.36	84.88
42	Soybeans	55.71	72.13	53.00	44.44
42	Cotton	---	---	---	---
43	Wheat	67.76	75.83	66.85	63.85
43	Feedgrains	100.80	118.30	100.19	89.60
43	Soybeans	57.96	73.83	55.25	48.27
43	Cotton	---	---	---	---
44	Wheat	70.63	78.85	68.42	63.83
44	Feedgrains	98.63	114.33	96.58	83.38
44	Soybeans	61.02	77.48	56.61	46.51
44	Cotton	---	---	---	---
45	Wheat	61.77	68.87	57.22	53.69
45	Feedgrains	77.67	89.11	72.63	64.63
45	Soybeans	62.67	72.37	53.91	49.17
45	Cotton	---	---	---	---
46	Wheat	61.41	65.48	59.67	51.98
46	Feedgrains	71.98	77.56	70.49	61.01
46	Soybeans	59.61	64.82	55.76	46.04
46	Cotton	---	---	---	---
47	Wheat	53.58	57.92	51.25	47.88
47	Feedgrains	58.26	64.58	56.30	51.50
47	Soybeans	66.14	74.79	61.15	47.78
47	Cotton	---	---	---	---
48	Wheat	51.27	56.14	48.49	45.31

Table 13 (Continued)

Rural area	Crop	Typical-farm structure	Small-farm structure	Medium-farm structure	Large-farm structure
			(1972 dollars)		
48	Feedgrains	69.68	79.35	66.38	59.33
48	Soybeans	62.77	71.28	57.62	46.21
48	Cotton	---	---	---	---
49	Wheat	53.11	60.15	49.28	44.28
49	Feedgrains	77.93	90.62	73.91	62.13
49	Soybeans	63.36	73.57	57.03	44.24
49	Cotton	---	---	---	---
50	Wheat	62.13	65.54	61.77	58.00
50	Feedgrains	88.65	92.83	88.68	82.30
50	Soybeans	60.41	65.16	59.96	53.56
50	Cotton	---	---	---	---
51	Wheat	60.53	64.77	59.92	55.98
51	Feedgrains	89.12	98.95	89.10	80.08
51	Soybeans	56.14	62.71	55.20	49.54
51	Cotton	---	---	---	---
52	Wheat	56.80	59.53	59.00	53.78
52	Feedgrains	83.56	91.92	84.07	72.53
52	Soybeans	52.25	61.15	54.26	45.83
52	Cotton	---	---	---	---
53	Wheat	55.88	60.38	55.23	50.23
53	Feedgrains	80.90	88.46	80.83	72.16
53	Soybeans	54.00	61.67	52.79	45.43
53	Cotton	---	---	---	---
54	Wheat	57.67	63.09	57.01	52.77
54	Feedgrains	84.87	95.38	84.99	76.23
54	Soybeans	56.43	66.66	55.16	48.41
54	Cotton	---	---	---	---

Table 13 (Continued)

Rural area	Crop	Typical-farm structure	Small-farm structure	Medium-farm structure	Large-farm structure
		(1972 dollars)			
55	Wheat	63.50	71.55	61.30	57.94
55	Feedgrains	94.43	108.61	92.08	84.42
55	Soybeans	57.89	69.90	55.45	51.39
55	Cotton	---	---	---	---
56	Wheat	46.94	57.74	51.25	42.80
56	Feedgrains	63.12	75.47	64.95	57.59
56	Soybeans	50.83	68.71	57.21	43.24
56	Cotton	212.63	216.88	211.14	181.45
57	Wheat	45.22	54.28	48.26	41.75
57	Feedgrains	95.63	112.56	85.57	68.79
57	Soybeans	67.17	91.35	67.67	56.41
57	Cotton	244.88	323.05	295.70	221.72
58	Wheat	64.23	76.33	64.07	60.34
58	Feedgrains	92.89	100.49	88.56	72.14
58	Soybeans	60.63	77.54	62.24	53.16
58	Cotton	255.63	250.16	260.92	207.74
59	Wheat	58.60	69.93	58.44	54.95
59	Feedgrains	87.20	94.46	83.08	67.40
59	Soybeans	58.60	73.33	58.37	49.50
59	Cotton	250.10	244.62	255.41	202.11
60	Wheat	47.46	57.65	51.54	43.59
60	Feedgrains	58.81	71.40	60.68	53.18
60	Soybeans	52.41	68.81	58.26	45.45
60	Cotton	179.70	183.16	178.48	154.32
61	Wheat	46.75	51.32	47.14	44.60
61	Feedgrains	77.25	83.52	73.35	57.78
61	Soybeans	62.69	82.25	67.01	54.67

Table 13 (Continued)

Rural area	Crop	Typical-farm structure	Small-farm structure	Medium-farm structure	Large-farm structure
			(1972 dollars)		
61	Cotton	150.50	157.57	144.41	160.89
62	Wheat	51.48	56.61	53.23	48.41
62	Feedgrains	67.68	78.13	67.62	52.02
62	Soybeans	61.98	85.18	66.08	54.64
62	Cotton	181.69	197.45	176.37	134.0
63	Wheat	57.15	61.30	55.91	53.53
63	Feedgrains	90.92	100.43	91.90	72.12
63	Soybeans	63.19	76.35	62.34	51.16
63	Cotton	161.33	169.36	158.11	147.05
64	Wheat	60.59	69.09	59.53	51.93
64	Feedgrains	82.56	93.57	81.19	67.65
64	Soybeans	65.29	81.87	64.54	48.78
64	Cotton	---	---	---	---
65	Wheat	54.16	61.92	52.05	48.82
65	Feedgrains	83.13	96.65	81.11	73.90
65	Soybeans	56.64	68.98	54.14	49.96
65	Cotton	---	---	---	---
66	Wheat	46.56	49.64	46.14	43.49
66	Feedgrains	74.23	79.17	73.75	68.90
66	Soybeans	55.52	59.61	55.00	50.65
66	Cotton	---	---	---	---
67	Wheat	44.01	43.27	45.76	38.05
67	Feedgrains	75.14	75.83	70.53	65.80
67	Soybeans	55.98	59.27	54.66	50.31
67	Cotton	---	---	---	---
68	Wheat	47.83	49.24	45.76	42.28
68	Feedgrains	69.55	77.57	73.72	67.79

Table 13 (Continued)

Rural area	Crop	Typical-farm structure	Small-farm structure	Medium-farm structure	Large-farm structure
			(1972 dollars)		
68	Soybeans	57.54	63.23	57.88	51.28
68	Cotton	---	---	---	---
69	Wheat	47.28	49.39	46.54	44.69
69	Feedgrains	73.98	76.90	72.91	69.83
69	Soybeans	56.14	58.85	55.07	51.47
69	Cotton	---	---	---	---
70	Wheat	48.34	51.28	47.83	45.33
70	Feedgrains	74.00	78.75	73.67	69.11
70	Soybeans	56.87	61.20	56.44	51.64
70	Cotton	---	---	---	---
71	Wheat	48.67	50.78	47.94	46.08
71	Feedgrains	76.87	79.90	75.76	72.56
71	Soybeans	55.78	58.48	54.71	51.11
71	Cotton	---	---	---	---
72	Wheat	42.51	44.49	41.82	40.08
72	Feedgrains	71.37	74.27	70.32	67.27
72	Soybeans	55.63	58.34	54.57	50.96
72	Cotton	---	---	---	---
73	Wheat	54.13	60.31	51.93	47.79
73	Feedgrains	67.85	75.59	64.93	59.92
73	Soybeans	43.75	48.55	41.46	39.22
73	Cotton	---	---	---	---
74	Wheat	50.85	52.96	50.07	47.96
74	Feedgrains	72.71	76.24	72.60	64.41
74	Soybeans	46.90	49.54	46.09	41.32
74	Cotton	---	---	---	---
75	Wheat	54.94	59.43	53.11	49.86

Table 13 (Continued)

Rural area	Crop	Typical-farm structure	Small-farm structure	Medium-farm structure	Large-farm structure
			(1972 dollars)		
75	Feedgrains	75.53	80.23	71.02	63.02
75	Soybeans	52.04	58.78	49.44	40.17
75	Cotton	---	---	---	---
76	Wheat	57.93	63.32	55.73	51.83
76	Feedgrains	59.19	63.21	55.33	48.48
76	Soybeans	59.57	66.88	56.75	46.71
76	Cotton	---	---	---	---
77	Wheat	50.29	55.76	51.17	43.66
77	Feedgrains	62.58	69.39	63.94	55.03
77	Soybeans	41.75	47.43	41.94	32.90
77	Cotton	---	---	---	---
78	Wheat	54.83	60.94	53.26	48.15
78	Feedgrains	55.55	61.49	54.71	48.67
78	Soybeans	46.05	33.92	45.18	36.02
78	Cotton	---	---	---	---
79	Wheat	42.16	49.65	40.73	35.48
79	Feedgrains	40.95	49.93	39.55	32.74
79	Soybeans	50.41	60.83	47.44	35.80
79	Cotton	---	---	---	---
80	Wheat	42.97	50.92	40.22	35.67
80	Feedgrains	41.37	48.85	38.82	33.54
80	Soybeans	55.91	66.58	52.71	42.13
80	Cotton	---	---	---	---
81	Wheat	39.77	45.09	38.17	34.59
81	Feedgrains	38.05	43.71	36.28	32.16
81	Soybeans	53.38	62.75	50.36	40.30
81	Cotton	---	---	---	---

Table 13 (Continued)

Rural area	Crop	Typical-farm structure	Small-farm structure	Medium-farm structure	Large-farm structure
			(1972 dollars)		
82	Wheat	36.28	39.52	34.75	32.49
82	Feedgrains	30.41	33.01	28.87	28.14
82	Soybeans	---	---	---	---
82	Cotton	---	---	---	---
83	Wheat	47.26	54.34	45.36	38.17
83	Feedgrains	42.74	48.56	41.93	35.01
83	Soybeans	---	---	---	---
83	Cotton	---	---	---	---
84	Wheat	37.47	45.05	34.59	32.03
84	Feedgrains	42.41	48.63	41.10	38.12
84	Soybeans	36.44	43.38	34.47	32.56
84	Cotton	---	---	---	---
85	Wheat	44.94	49.69	45.00	39.28
85	Feedgrains	51.86	57.13	51.27	43.83
85	Soybeans	59.78	67.25	58.06	49.73
85	Cotton	---	---	---	---
86	Wheat	40.57	48.14	39.60	33.12
86	Feedgrains	46.34	51.40	45.64	40.82
86	Soybeans	41.56	47.53	39.77	35.70
86	Cotton	---	---	---	---
87	Wheat	41.14	47.58	40.71	33.90
87	Feedgrains	51.10	56.34	50.61	44.13
87	Soybeans	41.47	48.74	39.11	35.05
87	Cotton	---	---	---	---
88	Wheat	45.56	51.76	44.92	39.23
88	Feedgrains	53.19	59.26	52.10	46.26
88	Soybeans	46.22	52.83	44.01	41.05

Table 13 (Continued)

Rural area	Crop	Typical-farm structure	Small-farm structure	Medium-farm structure	Large-farm structure
		(1972 dollars)			
88	Cotton	---	---	---	---
89	Wheat	43.26	48.89	41.56	39.39
89	Feedgrains	53.88	57.83	53.92	49.12
89	Soybeans	41.79	45.31	40.90	38.57
89	Cotton	---	---	---	---
90	Wheat	62.31	78.17	55.21	54.63
90	Feedgrains	86.52	95.06	85.82	73.59
90	Soybeans	53.97	61.68	52.14	45.20
90	Cotton	---	---	---	---
91	Wheat	43.43	47.83	43.78	36.86
91	Feedgrains	60.13	68.07	60.59	50.27
91	Soybeans	---	---	---	---
91	Cotton	---	---	---	---
92	Wheat	44.51	54.04	41.93	36.73
92	Feedgrains	74.80	83.47	73.27	60.06
92	Soybeans	---	---	---	---
92	Cotton	---	---	---	---
93	Wheat	41.30	45.04	38.96	35.96
93	Feedgrains	94.76	100.89	92.50	83.17
93	Soybeans	51.50	58.51	48.68	44.48
93	Cotton	---	---	---	---
94	Wheat	44.26	49.16	44.07	37.30
94	Feedgrains	78.97	86.25	79.28	69.67
94	Soybeans	50.80	55.76	51.39	44.07
94	Cotton	---	---	---	---
95	Wheat	54.98	60.62	54.14	43.43
95	Feedgrains	82.80	90.32	80.60	69.56

Table 13 (Continued)

Rural area	Crop	Typical-farm structure	Small-farm structure	Medium-farm structure	Large farm structure
			(1972 dollars)		
95	Soybeans	49.13	58.79	46.34	37.87
95	Cotton	---	---	---	---
96	Wheat	65.45	75.44	64.03	47.08
96	Feedgrains	89.00	105.20	87.43	72.62
96	Soybeans	64.28	78.59	57.50	41.18
96	Cotton	---	---	---	---
97	Wheat	64.78	75.64	62.84	47.56
97	Feedgrains	84.65	97.20	81.62	68.09
97	Soybeans	63.45	79.15	56.23	41.54
97	Cotton	---	---	---	---
98	Wheat	64.81	75.15	63.01	48.05
98	Feedgrains	77.47	89.22	74.98	61.79
98	Soybeans	62.67	78.49	55.67	40.95
98	Cotton	---	---	---	---
99	Wheat	65.20	76.15	62.70	49.66
99	Feedgrains	73.43	86.71	69.92	58.23
99	Soybeans	63.20	79.46	55.53	42.42
99	Cotton	---	---	---	---
100	Wheat	52.75	61.91	49.87	42.35
100	Feedgrains	74.49	86.77	73.67	63.90
100	Soybeans	53.01	60.30	49.31	41.19
100	Cotton	---	---	---	---
101	Wheat	56.67	67.62	52.57	46.04
101	Feedgrains	67.50	78.21	64.07	55.80
101	Soybeans	55.25	64.95	50.00	41.62
101	Cotton	---	---	---	---
102	Wheat	53.48	65.46	50.98	43.17

Table 13 (Continued)

Rural area	Crop	Typical-farm structure	Small-farm structure	Medium-farm structure	Large-farm structure
			(1972 dollars)		
102	Feedgrains	61.42	74.57	59.40	49.70
102	Soybeans	54.26	65.73	40.45	40.25
102	Cotton	---	---	---	---
103	Wheat	43.68	52.97	42.51	38.58
103	Feedgrains	57.25	65.50	55.98	48.58
103	Soybeans	44.23	51.87	42.31	35.04
103	Cotton	---	---	---	---
104	Wheat	37.61	43.40	37.96	35.32
104	Feedgrains	58.90	63.68	56.37	53.05
104	Soybeans		61.03	42.68	35.65
104	Cotton	---	---	---	---
105	Wheat	50.19	60.93	46.79	37.11
105	Feedgrains	59.47	72.26	53.95	42.88
105	Soybeans	49.35	67.23	42.42	32.46
105	Cotton	118.02	120.33	110.43	96.02
106	Wheat	39.22	43.69	38.00	33.81
106	Feedgrains	47.79	53.87	45.73	39.44
106	Soybeans	47.57	56.76	45.53	35.57
106	Cotton	118.90	121.22	111.33	96.90
107	Wheat	36.82	41.32	35.70	33.10
107	Feedgrains	56.90	62.27	55.06	45.22
107	Soybeans	---	---	---	---
107	Cotton	128.18	132.07	122.17	107.75
108	Wheat	47.89	63.74	41.75	31.99
108	Feedgrains	61.83	82.40	51.06	39.86
108	Soybeans	57.76	84.76	45.89	35.90
108	Cotton	170.02	190.13	135.40	132.11

Table 13 (Continued)

Rural area	Crop	Typical-farm structure	Small-farm structure	Medium-farm structure	Large-farm structure
			(1972 dollars)		
109	Wheat	47.60	53.43	46.89	36.00
109	Feedgrains	65.60	77.69	50.04	50.09
109	Soybeans	50.46	65.18	44.37	37.85
109	Cotton	167.16	189.03	135.84	124.06
110	Wheat	45.13	48.89	44.78	37.81
110	Feedgrains	67.97	76.44	64.75	54.30
110	Soybeans	51.66	60.22	48.64	43.31
110	Cotton	161.84	175.78	146.75	123.38
111	Wheat	38.43	46.13	36.84	31.86
111	Feedgrains	48.11	55.57	44.45	38.83
111	Soybeans	38.65	44.37	36.84	32.72
111	Cotton	116.38	124.43	107.00	83.93
112	Wheat	49.08	63.76	48.68	41.16
112	Feedgrains	83.25	98.41	81.09	74.40
112	Soybeans	40.22	52.94	39.20	33.30
112	Cotton	197.84	278.54	194.22	161.11
113	Wheat	37.10	44.04	39.98	29.47
113	Feedgrains	42.71	50.05	44.39	35.26
113	Soybeans	---	---	---	---
113	Cotton	103.75	121.22	92.96	80.75
114	Wheat	42.45	45.58	42.81	38.45
114	Feedgrains	61.11	72.66	62.57	55.34
114	Soybeans	43.38	55.61	44.64	35.56
114	Cotton	139.14	156.42	124.30	111.97
115	Wheat	40.84	54.73	40.81	30.74
115	Feedgrains	44.78	58.33	42.21	31.38
115	Soybeans	37.78	63.42	42.73	32.88

Table 13 (Continued)

Rural area	Crop	Typical-farm structure	Small-farm structure	Medium-farm structure	Large-farm structure
			(1972 dollars)		
115	Cotton	142.21	168.37	121.68	95.78
116	Wheat	43.65	54.33	42.15	36.44
116	Feedgrains	48.10	61.42	46.00	39.65
116	Soybeans	---	---	---	---
116	Cotton	116.92	135.39	106.51	84.74
117	Wheat	40.82	50.51	41.78	32.24
117	Feedgrains	53.12	64.47	52.28	41.67
117	Soybeans	43.89	58.72	43.25	32.94
117	Cotton	127.81	143.88	122.04	88.82
118	Wheat	39.39	45.80	43.71	28.74
118	Feedgrains	51.94	62.43	52.68	37.71
118	Soybeans	48.47	58.95	43.48	33.17
118	Cotton	147.40	167.83	129.27	107.97
119	Wheat	---	---	---	---
119	Feedgrains	73.35	77.34	70.89	64.18
119	Soybeans	42.96	55.13	47.16	39.32
119	Cotton	188.73	196.29	181.57	151.88
120	Wheat	---	---	---	---
120	Feedgrains	103.24	164.30	99.12	78.04
120	Soybeans	83.16	156.17	75.56	58.06
120	Cotton	229.98	335.42	210.44	190.25
121	Wheat	---	---	---	---
121	Feedgrains	106.78	127.62	82.01	67.26
121	Soybeans	---	---	---	---
121	Cotton	196.23	275.35	186.48	155.45
122	Wheat	40.67	46.63	44.14	32.27
122	Feedgrains	51.76	63.41	50.92	39.86

Table 13 (Continued)

Rural area	Crop	Typical-farm structure	Small-farm structure	Medium-farm structure	Large-farm structure
			(1972 dollars)		
122	Soybeans	---	---	---	---
122	Cotton	158.33	170.33	141.36	131.27
123	Wheat	---	---	---	---
123	Feedgrains	68.84	79.64	62.21	52.48
123	Soybeans	---	---	---	---
123	Cotton	144.50	155.75	132.67	115.79
124	Wheat	33.09	40.78	32.89	29.46
124	Feedgrains	60.43	72.98	59.64	51.58
124	Soybeans	---	---	---	---
124	Cotton	179.10	201.06	170.65	127.54
125	Wheat	---	---	---	---
125	Feedgrains	91.11	110.41	94.98	83.74
125	Soybeans	---	---	---	---
125	Cotton	223.16	228.57	238.71	177.89
126	Wheat	79.18	94.86	78.56	68.81
126	Feedgrains	71.66	91.40	68.50	56.53
126	Soybeans	---	---	---	---
126	Cotton	175.91	202.01	148.02	125.38
127	Wheat	---	---	---	---
127	Feedgrains	111.38	128.05	107.95	99.75
127	Soybeans	58.43	84.47	66.31	57.73
127	Cotton	256.78	258.93	262.32	234.66
128	Wheat	45.93	53.42	42.39	36.66
128	Feedgrains	63.33	73.69	57.31	50.45
128	Soybeans	---	---	---	---
128	Cotton	167.50	174.24	138.72	112.50
129	Wheat	50.41	59.00	50.23	43.51

Table 13 (Continued)

Rural area	Crop	Typical-farm structure	Small-farm structure	Medium-farm structure	Large-farm structure
			(1972 dollars)		
129	Feedgrains	74.21	81.30	71.31	66.14
129	Soybeans	---	---	---	---
129	Cotton	141.50	147.16	127.91	126.05
130	Wheat	88.11	100.85	89.64	84.73
130	Soybeans	---	---	---	---
130	Cotton	180.79	171.77	192.36	167.82
131	Wheat	39.99	47.06	35.92	33.81
131	Feedgrains	70.84	83.53	67.92	55.00
131	Soybeans	---	---	---	---
131	Cotton	---	---	---	---
132	Wheat	50.67	59.17	51.09	40.15
132	Feedgrains	76.68	90.47	78.34	66.41
132	Soybeans	---	---	---	---
132	Cotton	---	---	---	---
133	Wheat	38.10	43.88	36.67	34.16
133	Feedgrains	56.49	65.36	54.62	47.17
133	Soybeans	---	---	---	---
133	Cotton	---	---	---	---
134	Wheat	44.05	57.48	48.51	39.52
134	Feedgrains	75.54	87.03	73.03	62.29
134	Soybeans	---	---	---	---
134	Cotton	---	---	---	---
135	Wheat	44.35	54.63	48.25	40.85
135	Feedgrains	54.19	62.64	55.14	46.80
135	Soybeans	---	---	---	---
135	Cotton	---	---	---	---
136	Wheat	40.63	53.24	44.54	37.30
136	Feedgrains	41.77	51.64	43.04	35.92

Table 13 (Continued)

Rural area	Crop	Typical-farm structure	Small-farm structure	Medium-farm structure	Large-farm structure
			(1972 dollars)		
136	Soybeans	---	---	---	---
136	Cotton	---	---	---	---
137	Wheat	31.95	36.47	32.50	30.08
137	Feedgrains	31.69	34.94	31.17	28.88
137	Soybeans	---	---	---	---
137	Cotton	---	---	---	---
138	Wheat	38.37	47.46	38.59	36.03
138	Feedgrains	35.14	43.46	34.37	32.03
138	Soybeans	---	---	---	---
138	Cotton	---	---	---	---
139	Wheat	43.17	54.90	47.34	38.18
139	Feedgrains	43.89	53.10	45.64	36.73
139	Soybeans	---	---	---	---
139	Cotton	---	---	---	---
140	Wheat	51.90	68.45	54.87	48.50
140	Feedgrains	56.29	69.43	54.89	48.33
140	Soybeans	---	---	---	---
140	Cotton	---	---	---	---
141	Wheat	50.10	74.01	54.78	46.62
141	Feedgrains	83.50	96.62	72.57	62.76
141	Soybeans	---	---	---	---
141	Cotton	---	---	---	---
142	Wheat	105.62	131.52	117.14	100.98
142	Feedgrains	107.38	143.73	119.07	99.39
142	Soybeans	---	---	---	---
142	Cotton	214.96	216.47	269.57	181.17
143	Wheat	94.56	112.09	102.35	88.63
143	Feedgrains	100.65	121.28	108.75	95.80
143	Soybeans	---	---	---	---

Table 13 (Continued)

Rural area	Crop	Typical-farm structure	Small-farm structure	Medium-farm structure	Large-farm structure
			(1972 dollars)		
143	Cotton	256.27	324.29	225.42	256.50
144	Wheat	49.23	74.05	59.14	45.99
144	Feedgrains	61.25	84.96	68.82	55.37
144	Soybeans	---	---	---	---
144	Cotton	228.58	260.02	209.71	223.36
145	Wheat	60.80	85.37	68.89	54.59
145	Feedgrains	60.38	86.79	68.64	54.00
145	Soybeans	---	---	---	---
145	Cotton	---	---	---	---
146	Wheat	47.57	57.79	47.21	44.14
146	Feedgrains	54.33	67.11	52.73	47.70
146	Soybeans	---	---	---	---
146	Cotton	---	---	---	---
147	Wheat	51.17	60.86	53.04	48.07
147	Feedgrains	44.70	57.05	45.84	39.80
147	Soybeans	---	---	---	---
147	Cotton	---	---	---	---
148	Wheat	53.60	63.21	55.46	50.53
148	Feedgrains	61.14	76.37	62.54	55.08
148	Soybeans	---	---	---	---
148	Cotton	---	---	---	---
149	Wheat	52.56	72.49	55.06	48.64
149	Feedgrains	57.29	77.27	56.10	49.55
149	Soybeans	---	---	---	---
149	Cotton	---	---	---	---
150	Wheat	46.55	65.88	47.14	40.25
150	Feedgrains	74.40	95.48	72.90	65.30
150	Soybeans	---	---	---	---
150	Cotton	---	---	---	---

Land Base

Land serves as a major internal constraint in the programming model. In each rural area the land base for the crops included in the model is based on the historic acreages of those crops. The acreage of the seven crops in the model (corn grain, sorghum grain, barley, oats, wheat, soybeans, and cotton) in 1964 plus the number of acres diverted from production in that year form the models land base in each rural area (13). Nationally, this totals to 245.2 million acres of available cropland in the 150 rural areas.

In most regions, soybeans cannot be grown continuously because of the threat of disease. Therefore, soybean production is restrained to 50 percent of the available cropland in most rural areas (13). Recently, however, the Delta States have had more acres in soybeans than 50 percent of their land base would allow. In those rural areas in the Delta States, therefore, soybeans production is restrained to 70 percent of the available land base.

The programming model, if unrestrained, will allow complete resource mobility among commodities and regions. Since the time frame for this model is 1980, complete resource mobility is probably not attainable. Therefore, restraints are incorporated as lower bounds (except in Alternative E) to force production to occur in each rural area. For each crop these restraints are defined at 50 percent of the 1969 production in each rural area (71). In other words, each rural area must have at least 50 percent as many acres of each crop in production as it did in 1969. This restraint is removed for Alternative E.

Transportation Costs

Within the programming model, 1603 transportation activities are defined at the consuming region level. These transportation activities allow the production of a commodity in one region to satisfy the demand for that commodity in another region. No transportation activities are specified for grain used to satisfy demands in the consuming region in which it is produced. Transportation costs are incurred only when grain is transported between two consuming regions.

To reduce the size of the model and, therefore reduce computational costs, transportation activities are only defined where it is likely they will be used. For example, some consuming regions don't have production activities defined for oilmeals or spring wheat. Therefore, no transportation activities are specified for these commodities in those regions. In other cases, transportation is very unlikely to occur. For example, the transportation of feed grains from the Corn Belt to the New England states is quite likely, but the reverse is not reasonable. Therefore, no feed grains transportation activities are defined from the New England states to states in the Corn Belt.

Within each consuming region, one city must be designated to represent the export/import center of that region. These points are defined to be approximately centered with respect to consumption patterns in that region (76). In addition, these cities must have access to rail transportation and, in most cases, are near the geographical center of the region. These 31 cities are presented in Table 14.

Rail rates are assumed to adequately reflect transportation costs between any two consuming regions. These costs were originally derived by Whittlesey (76) and Skold (37) from the 1962 ICC tariff schedule. To convert these costs to 1972 dollars, these rates were updated by the change in railroad freight rates from 1962 to 1972 (42).

Within the programming model transportation activities are defined for spring and winter wheat, feed grains, and oilmeals. Costs for these activities are expressed in dollars per hundred pounds of feed units of each grain. To develop transportation costs for feed grains, the cost of transporting corn grain, sorghum grain, barley, and oats was weighted by the 1950-59 average production of each crop in each consuming region. Transportation costs for spring and winter wheat are assumed to be equal.

Table 14. Transportation centers selected for each of the 31 consuming regions

Region	City	State
1	Boston	Massachusetts
2	Binghampton	New York
3	Richmond	Virginia
4	Augusta	Georgia
5	Montgomery	Alabama
6	Tallahasse	Florida
7	Nashville	Tennessee
8	Indianapolis	Indiana
9	Columbus	Ohio
10	Lansing	Michigan
11	Minneapolis	Minnesota
12	Madison	Wisconsin
13	Des Moines	Iowa
14	Jefferson City	Missouri
15	Peoria	Illinois
16	Little Rock	Arkansas
17	Jackson	Mississippi
18	Austin	Texas
19	Oklahoma City	Oklahoma
20	Abilene	Kansas
21	Kearney	Nebraska
22	Bismarck	North Dakota
23	Pierre	South Dakota
24	Helena	Montana
25	Casper	Wyoming
26	Denver	Colorado
27	Phoenix	Arizona
28	Salt Lake City	Utah
29	Yakima	Washington
30	Bend	Oregon
31	Fresno	California

Wheat-to-Feed Grains Transfer Costs

For each of the 31 consuming regions, activities are included which allow the use of either spring or winter wheat (or both if both are defined in that region) as feed grains. An artificial penalty is attached as a cost to each of these activities. This penalty reflects the lower preference of livestock producers for wheat as feed. To estimate this penalty, a per unit cost was chosen which resulted in a wheat/feed grains substitution under Alternative A which is consistent with recent actual quantities. This same penalty is then used for the other six alternatives. While this in an arbitrary process, it does allow changes in the wheat/feed grains price ratio for different alternatives to be reflected in the quantity of wheat substituted for feed grains.

CHAPTER V. RESULTS FOR THE SEVEN MODEL ALTERNATIVES

Using the programming model results as a base, estimates for the variables of interest are determined for the seven model alternatives. These results are presented and compared in this section of the report.

National Output and Acreage

One set of variables directly derivable from the programming model is the national production, acreage, and yield estimates for wheat, feed grains, soybeans, and cotton (see Table 15). Of the seven model alternatives, Alternative A which incorporates trend level exports and the typical farming structure is most comparable to the recent-year data given in Table 15. The production of feed grains and soybeans under this alternative is much greater than in 1972. Production of these commodities is estimated to increase by 23 and 49 percent, respectively. In contrast wheat production under Alternative A is estimated to be only slightly greater than in the recent periods and cotton lint production would be less than in 1972 but greater than the 1969-72 average.

The increases in production noted for feed grains and soybeans under Alternative A require more acres than were devoted to these crops in 1972 or in the 1969-72 period. For Alternative A, the total acreage requirement of the four

Table 15. Estimated production, acreages and yields for each of the model alternatives with 1969-72 average and 1972 values for comparison

	1969-72 average[a]	1972[a]	Model alternatives A	B	C	D	E	F	G
			Total production (millions)						
Wheat (bu.)	1,489.2	1,544.8	1614	1796	1728	1747	1798	1591	1431
Feed grains (tons)	186.3	199.8	245	249	251	252	249	247	251
Soybeans (bu.)	1,179.8	1,282.9	1906	2161	2159	2163	2156	1906	1909
Cotton (bales)	11.1	13.6	11.5	12.3	12.3	12.3	12.3	11.5	11.5
			Harvested acreage (million acres)						
Total four crops	199.9	200.2	226.7	249.4	249.2	249.4	244.2	227.7	229.3
Wheat	46.4	47.3	45.3	52.2	49.8	50.3	50.5	44.8	41.7
Feed grains	98.8	94.1	111.2	117.6	119.3	118.1	114.7	113.0	115.7
Soybeans	43.0	45.8	60.8	69.5	69.9	70.9	69.6	60.4	61.4
Cotton	11.7	13.0	9.4	10.1	10.2	10.1	9.4	9.5	10.5
			Yield per harvested acre						
Wheat (bu.)	31.6	32.7	35.6	34.4	34.7	34.7	35.6	35.5	34.3
Feed grains (bu.)[b]	67.3	75.7	78.7	75.6	75.1	76.2	77.5	78.1	77.5
Soybeans (bu.)	27.4	27.9	31.3	31.1	30.9	30.5	31.0	31.6	31.1
Cotton (lbs.)	451.2	495.0	587	585	579	585	628	581	526

[a]Source: (61,62,63).

[b]Feed grains yields are reported on a corn equivalent basis.

crops, 226.7 million acres, is 13 percent greater than in 1972. Hidden in that total increase are decreases of two million acres for wheat and 3.6 million acres for cotton. For each of the four commodities, per acre yields are estimated to be higher under Alternative A than in 1972. These yield increases are the dual result of increases in technology by 1980 and regional shifts in production. Regional production shifts in the model result partly because of the removal of government program restraints which were in effect in the 1969-72 period. The largest jump in yield would occur for cotton lint, increasing by 18 percent over its 1972 yield of 495 pounds per acre.

The export levels specified under Alternative B are 25 percent greater than for Alternative A. This percentage increase was determined because production at this level very nearly exhausts the land base of the model. Nationally the acreage required under Alternative B, 249.4 million acres, is 10 percent greater than for Alternative A and 25 percent greater than harvested in 1972. Of the 22.7 million acre increase over Alternative A, 15.6 million acres would be devoted to wheat and soybeans. Since a large portion of their production goes to export markets, production of these two commodities are greatly affected by an increase in exports. On a total production basis, a 25 percent increase in exports results in an 11 percent increase in wheat production, a 2 percent increase in feed grains production, a 13 percent increase in soybeans production, and a 7 percent increase in the production of cotton lint. The additional acreage required for Alternative B is concentrated on more marginal, lower-yielding cropland not in production under Alternative A. For all four of the commodities, cultivation of these areas results in a lower per acre yield under Alternative B than under Alternative A.

The same demand quantities, are specified for Alternatives B, C, D, and E; therefore any farm-size or locational differentials between them can be directly translated into changes in input requirements. In spite of their constant demand assumption, the production of wheat and feed grains varies among these four alternatives. This occurs because the programming model is allowed to satisfy part of its feed grains demand with the production of wheat, if their relative prices make that substitution profitable. Because of this substitution, feed grains production is two million tons greater under Alternative C than under Alternative B, while wheat production is 68 million bushels less. Since farm-size structure is the only parameter which varies between Alternatives B and C, this production shift implies that feed grains production would be relatively more profitable and wheat production less profitable when all farms are of medium size than when farms of all these sizes exist.

The acreage requirement is nearly constant for Alternatives B, C, and D. The acreage required for Alternative E, however, is 5.2 million acres less than for Alternative D. The assumption of complete resource mobility under Alternative E allows the production of each crop to concentrate in those regions best suited for it and results in higher per acre yields for the four commodities than under Alternative D. The largest yield increase is estimated for cotton lint. The 628 pound yield of cotton lint under Alternative E is 7 percent greater than under Alternative D. Since Alternatives D and E incorporate both the same demand quantities and the large-farm structure, Alternative E's yield increases are the direct result of the removal of the resource restraints associated with Alternative D.

Alternatives F and G compare the possible impacts of two different methods of implementing a government farm program designed to achieve a set of "target" prices. For Alternative F, the model operates as if there were no government controls. Deficiency payments compensate for the difference between market and "target" prices in this instance. Under Alternative G, regional acreage quotas (based on 1969 acreage allotments) are imposed to insure that market prices are equal to "target" prices. Imposition of these acreage quotas require 1.6 million more acres to be in production under Alternative G than would be required under Alternative F. This additional acreage is needed because per acre yields for all four commodities are lower under Alternative G. Again, the greatest yield impact is on cotton lint, decreasing by 9 percent when the acreage quotas are in effect.

Regional Distribution of Production

While national production and the acreage it requires are important variables, consideration of only these aggregate variables could mask some important regional comparisons. To highlight these comparisons, estimates of the total acreage required in each of the ten farm production regions are presented in Table 16. Because of rounding error, the national acreages presented in Table 16 vary slightly from those of Table 15. In addition, Tables 17, 18, 19, and 20 present the acreage requirements for each of the four crops (at the same regional level). The acreage estimates of Tables 17-20 do not include acreages from the White Areas but the estimates of Table 16 do include White Area production. Therefore the acreages in Tables 17-20 will not sum to those in Table 16. Although the programming model provides acreage data by 150 rural areas, because of space limitations we only present the data at the farm production region level.

Nationally, Alternative A requires almost 27 million more acres than were harvested in 1972. This increase, however, is not distributed evenly among the farm production regions.

Table 16. Estimates of total harvested acreage for each of the model alternatives for the United States and for each of the ten farm production regions with 1969-72 average and 1972 acreages for comparison

Region	1969-72 average[a]	1972[a]	Model alternatives A	B	C	D	E	F	G
			Million acres						
United States	199.8	200.2	226.9	249.5	249.5	249.7	244.1	227.9	229.4
Northeast	4.1	4.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Corn Belt	61.2	61.7	69.3	70.4	70.4	70.4	70.4	70.0	70.3
Lake States	19.5	19.8	23.9	24.3	24.3	24.3	24.3	23.9	23.9
Appalachian	8.7	9.2	7.6	9.9	9.9	9.9	9.1	6.6	7.7
Southeast	7.3	7.6	7.7	11.1	11.4	11.4	11.1	8.3	8.6
Delta States	12.7	13.0	12.3	13.7	13.7	13.7	13.5	12.6	12.1
Southern Plains	20.1	19.3	29.4	30.4	30.5	30.5	30.5	30.3	29.3
Northern Plains	46.2	45.8	49.0	60.9	60.5	60.7	57.2	48.8	52.3
Mountain	13.0	12.8	15.2	16.3	16.3	16.3	15.5	14.9	13.7
Pacific	7.0	7.0	7.5	7.5	7.5	7.5	7.5	7.5	6.5

[a]Source: (61,62,63).

Table 17. Estimates of acreage harvested for wheat for each of the model alternatives for the United States and for each of the ten farm production regions with 1969-72 average and 1972 acreages for comparison

Region	1969-72 average[a]	1972[a]	Model alternatives						
			A	B	C	D	E	F	G
			Thousand acres						
United States	46,417	47,284	44,140.3	51,005.7	48,573.9	49,089.7	49,338.9	43,591.2	40,480.0
Northeast	574	579	193.3	193.3	193.3	193.3	--	193.3	894.1
Corn Belt	3,799	4,013	2,982.9	2,427.4	2,427.4	2,475.7	2,349.7	2,772.1	3,416.3
Lake States	1,745	2,062	4,233.6	1,183.3	1,692.9	2,303.9	2,696.7	4,313.1	1,931.4
Appalachian	805	888	932.6	1,984.8	2,535.5	2,114.3	1,884.9	967.8	824.2
Southeast	377	428	406.8	1,964.0	1,170.1	1,449.8	1,744.8	397.9	229.1
Delta States	415	486	1,964.6	2,741.5	2,320.0	1,742.8	2,836.2	2,013.1	182.7
Southern Plains	6,096	5,900	7,498.2	7,555.4	7,286.1	7,278.0	8,185.4	7,073.0	6,263.2
Northern Plains	21,366	21,328	14,043.5	20,294.6	18,667.8	19,243.0	18,245.1	14,269.1	17,657.3
Mountain	7,609	7,632	7,762.2	8,538.8	8,331.4	8,166.3	6,941.4	7,469.2	6,375.9
Pacific	3,632	3,968	4,122.6	4,122.6	3,949.4	4,122.6	4,454.7	4,122.6	2,705.8

[a]Source: (61,62,63).

Table 18. Estimates of acreage harvested for feed grains for each of the model alternatives for the United States and for each of the ten farm production regions with 1969-72 averageaand 1972 acreages for comparison

Region	1969-72 average[a]	1972[a]	Model alternatives A	B	C	D	E	F	G
			Thousand acres						
United States	98,780	94,021	107,701.6	114,169.4	115,936.8	114,662.1	110,801.2	109,477.2	112,251.6
Northeast	3,065	2,858	3,292.8	3,082.4	3,082.4	3,082.4	3,276.1	3,292.8	2,591.9
Corn Belt	34,762	33,283	47,575.9	43,486.2	43,854.1	44,695.9	45,951.0	47,708.6	47,505.2
Lake States	14,114	13,707	13,225.3	14,904.0	14,695.3	13,945.9	12,653.8	13,409.3	15,297.1
Appalachian	4,126	3,871	1,759.4	2,097.1	1,888.8	1,888.8	1,423.6	1,861.7	1,757.9
Southeast	3,237	3,003	1,262.0	2,485.3	3,592.8	3,543.1	3,694.9	2,091.0	2,268.0
Delta States	834	651	222.8	529.1	990.9	1,568.0	1,932.4	529.1	839.5
Southern Plains	8,360	7,426	12,352.3	13,224.9	13,211.0	13,219.2	12,801.7	12,843.4	13,198.7
Northern Plains	22,731	22,343	21,997.2	27,973.1	27,853.6	25,959.0	22,827.1	21,434.4	21,253.1
Mountain	4,924	4,666	5,278.2	5,651.6	5,859.0	6,024.1	6,240.6	5,571.2	5,663.6
Pacific	2,629	2,213	735.7	735.7	908.9	735.7	--	735.7	1,876.6

[a]Source: (61,62,63).

Table 19. Estimates of acreage harvested for soybeans for each of the model alternatives for the United States and for each of the ten farm production regions with 1969-72 average and 1972 acreages for comparison

Region	1969-72 average[a]	1972[a]	Model alternatives A	B	C	D	E	F	G
			Thousand acres						
United States	42,996	45,698	60,334.2	69,128.0	69,423.5	70,386.2	69,240.4	59,932.9	60,897.0
Northeast	473	521	611.2	821.6	821.6	821.6	821.2	611.2	611.2
Corn Belt	22,333	24,178	18,451.2	24,190.8	23,822.9	22,932.8	21,949.8	19,273.9	18,975.2
Lake States	3,664	3,894	6,135.2	7,867.7	7,566.8	7,705.2	8,604.4	5,871.6	6,413.0
Appalachian	3,178	3,737	3,756.0	4,287.9	4,287.9	4,366.7	3,655.4	2,696.1	3,737.2
Southeast	2,446	2,782	5,416.1	5,687.0	5,492.3	5,625.6	5,581.3	4,868.7	5,408.7
Delta States	8,492	8,181	8,430.7	8,689.1	8,689.1	8,709.0	8,353.0	8,382.1	8,689.1
Southern Plains	368	380	4,673.2	4,838.7	4,838.7	4,838.7	4,267.6	5,193.1	3,797.6
Northern Plains	2,044	2,025	12,860.6	12,580.2	13,904.2	15,386.6	16,007.8	13,036.1	13,265.0
Mountain	--	--	--	--	--	--	--	--	--
Pacific	--	--	--	--	--	--	--	--	--

[a]Source: (61,62,63).

Table 20. Estimates of acreage harvested for cotton for each of the model alternatives for the United States and for each of the ten farm production regions with 1969-72 average and 1972 averages for comparison

Region	1969-72 average[a]	1972[a]	Model alternatives						
			A	B	C	D	E	F	G
						Thousand acres			
United States	11,665.2	12,983.8	9,336.7	9,954.0	10,053.8	10,033.0	9,252.3	9,405.1	10,363.8
Northeast	--	--	--	--	--	--	--	--	--
Corn Belt	315.7	406.1	148.6	148.6	148.6	148.6	2.5	148.6	356.3
Lake States	--	--	--	--	--	--	--	--	--
Appalachian	601.3	662.5	397.9	705.1	362.6	705.1	1,381.9	260.4	568.3
Southeast	1,266.6	1,361.3	559.9	847.4	1,046.8	683.5	--	803.5	599.2
Delta States	3,004.0	3,681.0	1,283.8	1,324.1	1,283.8	1,283.8	--	1,283.8	1,963.6
Southern Plains	5,290.5	5,544.5	4,477.7	4,460.1	4,743.2	4,743.2	4,824.5	4,743.2	5,655.1
Northern Plains	--	--	--	--	--	--	--	--	--
Mountain	445.0	465.1	1,004.9	1,004.9	1,004.9	1,004.9	1,175.9	701.7	496.7
Pacific	742.0	863.3	1,463.9	1,463.9	1,463.9	1,463.9	1,867.5	1,463.9	714.6

[a]Source: (61,62,63).

Instead, five regions (the Corn Belt, Lake States, Southern Plains, Northern Plains, and Mountain regions) would have sharp increases in acreage over 1972 and the other five regions (the Pacific, Northeast, Appalachian, Southeast, and Delta States regions) either would have decreases or small increases in acreage. For the five regions with major acreage shifts, the largest increases on a percentage basis are in the Lake States region, 21 percent, and the Southern Plains region, 52 percent.

The additional exports associated with Alternative B result in a 10 percent increase over Alternative A in the total number of acres required for harvest. Again this increase in acreage is not spread uniformly throughout the nation but instead is concentrated in three farm production regions; the Southeast, Appalachian and Northern Plains regions. These three regions accounted for 17.6 million acres, or 78 percent, of the total increase in acreage estimated between these two situations.

Increased exports cause pressures on the model's land base resulting in shifts among the ten regions in the mix of commodities they produce. Wheat production increases greatly in the Appalachian, Southeast, and Northern Plains regions but decreases by 3.1 million acres in the Lake States region. For feed grains, the Corn Belt region would have 4.1 million fewer acres in production under Alternative B than for Alternative A but the Northern Plains region would have six million additional acres under Alternative B. In addition, the Lake States, Southeast and Southern Plains regions are estimated to have increases in the acreage devoted to feed grains when exports are expanded.

Since the Corn Belt region would have fewer acres in feed grains under Alternative B, it then has the potential to expand its soybeans acreage. This region is estimated to have 24.2 million acres in soybeans in this situation, 5.7 million more than it had under Alternative A. The Lake States region is the only other region which would have a large increase in soybeans acreage under Alternative B.

Nationally, cotton acreage increases by 617,000 acres between Alternatives A and B. This acreage increase would be concentrated primarily in the Appalachian and Southeast regions. These two regions account for 96 percent of the increase in cotton acreage between Alternatives A and B.

The acreage requirements for Alternatives B, C and D remain fairly stable at both the national and regional level. This stability would result because the land base of the model is being utilized at full capacity in each of the situations.

However, significant shifts in land usage result between Alternatives D and E. These alternatives vary only in that the resource mobility restraints associated with Alternative D are removed for Alternative E. Therefore, Alternative E represents a maximum efficiency future where all farms would be large and resources would be completely mobile between crops and between geographical areas. The bulk of the 5.6 million acre cropland reduction under Alternative E occurs in the Northern Plains region which would have 3.5 million fewer acres in production in the maximum efficiency case. In this region the decrease in acreage is concentrated in reductions in feed grains production.

The location of cotton production is greatly affected by the removal of the resource mobility restraints. Under Alternative E, 780,000 fewer acres are devoted to cotton than under Alternative D. Regions which would have fewer acres in cotton under Alternative E are the Southeast, Corn Belt, and Delta States regions. In contrast, significant increases in cotton acreage would occur in the Appalachian and Pacific regions.

Alternatives F and G differ in that acreage quotas to limit the acreage devoted to wheat, feed grains, and cotton in each rural area are imposed for the latter case but not for the former. The more inefficient production patterns resulting from these quotas require an additional 1.5 million acres of cropland under Alternative G. The Northern Plains and Appalachian regions both would have significant increases in acreage for this case. In contrast, the Delta States, Southern Plains, Mountain, and Pacific regions would have sharp decreases in acreage under Alternative G.

The acreage quotas have a major impact on cotton production as Alternative G requires 959,000 more acres in cotton than does Alternative F. Increases in cotton acreage are concentrated in the Corn Belt, Appalachian, Delta States, and Southern Plains regions. Conversely under Alternative G the Southeast, Mountain, and Pacific regions are constrained to only 61 percent of their cotton acreage under Alternative F.

Supply Prices

For each of the model alternatives, the programming model generates those prices necessary to cover the cost of producing the quantity of output demanded in each instance. To determine these prices, the programming model chooses that rural area with the lowest production costs to enter the solution first. (Here land costs are not a part of the cost of production, but land owners are assumed to receive any residual return from production). It then selects rural areas with increasingly higher production costs until the specified demands for each alternative are exactly satisfied. Since the model operates as if agriculture were a perfectly competitive industry, the cost of production in the highest-cost rural area selected is the price applicable throughout the rest of the industry (abstracting for the moment from price differentials due to transportation costs). In those rural areas with lower costs than in the last rural area, the difference between their cost of production and the national price is considered to be a residual return to land.

Table 21 presents the national supply prices estimated in each of the seven model alternatives. These prices represent prices at the farm level and therefore don't include charges for transportation between consuming regions. The farm price estimated for both wheat and feed grains under Alternative A is nearly equal to their 1972 price but is significantly higher than their 1969-72 average price. The estimated supply price for cotton lint under Alternative A, 33.7 cents per pound, is well above both the 1972 price and the 1969-72 average price. Under Alternative A, no acreage would be diverted from production. The availability of this additional cropland allows a tremendous increase in soybean production over 1972 even though the estimated price of soybeans, $2.85 per bushel, remains significantly lower than in 1972. The per bushel price of soybeans under Alternative A, however, is only 27 cents less than the 1969-72 average price.

As production is expanded to satisfy additional export demands, land with higher per acre production costs must be utilized leading to increases in the estimated supply price. This relationship is evidenced by the price differentials between Alternatives A and B. (Expanded exports are the only difference between these two situations.) For each of the

Table 21. Farm prices for each of the model alternatives with 1969-72 average and 1972 prices for comparison[a]

	1969-72 average[b]	1972[b]	Model alternatives A	B	C	D	E	F	G
Wheat ($/bu.)	1.42	1.76	1.81	2.62	2.63	2.29	1.74	1.79	2.05
Feed grains ($/bu.)	1.21	1.32	1.37	1.99	1.96	1.71	1.46	1.35	1.38
Soybeans ($/bu.)	3.12	4.13	2.85	4.67	4.56	3.93	3.26	2.78	3.00
Cotton (¢/lb.)	25.1	26.7	33.7	36.9	36.0	30.0	23.1	33.0	38.0

[a]All prices for 1980 are reported in 1972 dollars with no adjustment for inflation to 1980.

[b]Source: (59,60).

commodities, per unit prices under Alternative B rise sharply over their level under Alternative A. These price differentials are 81 cents for wheat, 62 cents for feed grains, $1.82 for soybeans, and 3.2 cents for cotton lint. The relatively large increase for soybeans, 64 percent over Alternative A, again reflects the greater reliance of soybeans on export demand.

Alternatives B and C both assume expanded exports but the former incorporates the typical-farm structure while the latter incorporates the medium-farm structure. Per unit prices are nearly equal between these two situations. This indicates that an industry comprised of all medium farms could provide these commodities for a similar cost as one composed of a mixture of small, medium, and large farms.

Comparison of farm supply prices under Alternatives D and B provides an indication of possible scale economics associated with a farming industry composed of all large farms. For all four commodities the supply price necessary to produce the demands associated with Alternative D is significantly lower those under Alternative B. Per unit price differentials are 33 cents for wheat, 28 cents for feed grains, 74 cents for soybeans, and 6.9 cents for cotton lint.

Resource mobility restraints, based on 1969 production patterns, are incorporated in each of the model alternatives except Alternative E. Comparison of supply prices under this situation with those of Alternative D indicates potential reductions in crop prices if these mobility restraints could be removed. Potential reductions in price are noted for each of the four crop commodities. Per unit, these price differentials are 55 cents for wheat, 25 cents for feed grains, 67 cents for soybeans, and 6.9 cents for cotton lint.

For wheat, feed grains, and cotton lint the supply prices under Alternative G equal the "target" price levels of the Agricultural and Consumer Protection Act of 1973 (43). For each rural area, acreage quotas are imposed under this alternative to insure that the model determined supply prices reach the "target" levels. For Alternative F, however, the model is allowed to determine a supply price without these acreage quotas. Therefore, price differentials between these two situations reflect the direct price impact of these supply restraints. Per unit price reductions of 26 cents for wheat, 3 cents for feed grains, 22 cents for soybeans, and 5 cents for cotton lint are estimated for Alternative F (as compared to Alternative G).

Farm Sector Returns

The linear programming model provides data on production and price for four major crop commodities; wheat, feed grains, soybeans, and cotton. Although this data is itself interesting and useful, many observers of American agriculture are also concerned with variables such as cash receipts to the farm sector, net income from farming, and per farm net income. To provide information regarding these variables for each model alternative, procedures were developed which tie the programming model results to the value of these variables. The procedures used to estimate cash receipts and production expenses are described in detail in Appendix B.

To calculate demands for the major livestock products, it is necessary to specify a value for the farm price of these products. In Chapter III, the equations used to estimate per capita consumption of the major livestock products contained their retail prices as explanatory variables. By incorporating a constant farm-to-retail price spread (74), these retail livestock-prices can be related to farm prices. This procedure is described more fully by Koo (21). An iterative process is employed to arrive at prices for these livestock products consistent with the supply prices of the crop commodities resulting from the programming model. Basically this process operates as follows: First, a price is chosen for each livestock product and a demand quantity for each product is estimated based on this price. From this livestock demand, a derived demand for livestock feed is computed and added to the other demand categories for feed grains and soybeans. The programming model then determines supply prices for the crop commodities based partially on the demand for livestock. The programming model crop prices are then compared with the initial livestock prices and a judgment is made as to their relative consistancy.

If the livestock price is judged too high relative to the crop prices (i.e. 60¢/pound beef vs. 90¢/bushel corn), the initial livestock price is lowered. (A reverse process is employed if livestock prices are judged to be too low.) Lowering the price of livestock increases the quantity of livestock demanded, thereby increasing the quantity of livestock feed needed. The resulting increase in crop production will be forced into areas with higher production costs in the model, raising the national supply price of the crops. This process continues until prices of both the crop commodities and the livestock products are judged to be consistent. The goal of this process is not to predict the price of livestock in 1980. Rather, the process is designed to contribute to answering the following question: Given the initial conditions and parameters (including livestock prices) of Alternative A, if those conditions are parameters vary what is the direction and magnitude of the impacts of those changing conditions?

In the analysis one set of livestock prices are associated with each different quantity of livestock products demanded. These three sets of prices are presented in Table 22.

Table 22. Selected prices of major livestock products for different situations in the analysis

Livestock class	Model alternatives		
	A,F	G	B,C,D,E
Beef (¢/lb.)	40.0	42.0	48.0
Pork (¢/lb.)	31.0	33.0	37.0
Broilers (¢/lb.)	20.0	21.0	24.0
Lamb (¢/lb.)	34.0	36.0	41.0

Incorporating the above livestock price data in the procedures of Appendix B, estimates of cash receipts can be made for each situation. These estimates, as well as the other national income variables, are given in Table 23. Estimated cash receipts under Alternative A, $68.9 billion, are almost $8.3 billion, or 14 percent, greater than in 1972. However, production expenses for the model situation are also higher than in 1972. Therefore net receipts estimated under Alternative A increase by $5.4 billion over 1972. Since no government payments are included, the estimated net return under Alternative A is equal to estimated net farm income. In 1972, however, almost $4 billion dollars was paid to the farm sector for government sources. This explains why total net farm income under Alternative A is nearly equal to the 1972 figure even though estimated net returns are $4.6 billion

Table 23. Estimates of total farm income and net farm income per commercial farm for each of the model alternatives with 1969-72 average and 1972 data for comparison

	1969-72 average[a]	1972[a]	Model alternatives A	B	C	D	E	F	G
	(Million dollars)[b]								
Cash receipts from farm marketings	53,018.5	60,671.0	68,939.5	83,044.7	82,527.2	79,107.6	75,074.7	68,656.9	70,838.8
Production expenses[c]	43,372.8	49,167.0	52,009.1	53,721.9	53,725.8	48,331.2	47,294.0	51,997.4	51,949.9
Net receipts from farm marketings	9,645.8	11,504.0	16,930.4	29,322.8	28,801.4	30.776.4	27,780.7	16,659.5	18,888.9
Nonmoney income and inventory charge[d]	4,458.3	4,879.0	4,050.0	4,050.0	4,050.0	4,050.0	4,050.0	4,050.0	4,050.0
Net returns from farming	14,104.0	16,383.0	20,980.4	33,372.8	32,851.4	34,826.4	31,830.7	20,709.4	22,938.9
Income from governmental sources[e]	3,654.3	3,961.0	0	0	0	0	0	812.5	687.0
Total net farm income	17,758.3	20,344.0	20,980.4	33,372.8	32,851.4	34,826.4	31,830.7	21,522.0	23,625.9

Number of commercial farms (thousands)[f]	1,796.3	1,833.0	1,720.7	1,900.0	2,234.8	1,072.1	1,056.5	2,017.7	2,008.1
Net farm income for commercial farm (dollars)	9,886	11,099	12,193	17,565	14,700	32,484	30,128	10,667	11,765

[a]Source: (50).

[b]All dollar values are measured in 1972 dollars with no adjustment for inflation to 1980.

[c]Production expenses for Alternatives A and B were estimated by updating the production expense equations in: (22). Production expenses for Alternatives F and G are estimated by multiplying the production expenses estimated for Alternative A by the change in the value of the objective function between Alternative A and Alternatives F and G. Production expenses for Alternatives C, D and E are estimated in a similar manner but are related to Alternative B.

[d]Includes the value of home consumption and the rental value of farm dwellings.

[e]Includes ACP, Great Plains Conservation, Sugar Act and Wool Act payments as well as payments under the Wheat, Feed Grains and Cotton programs.

[f]Source: (68).

greater than in 1972.

To relate these total income figures to individual farming operations, estimates of the number of commercial farms required for each of the model alternatives are made. Essentially, the trend in size of farms from 1959 to 1969 in each state is projected to 1980 for each farm-size structure. These projections of average farm size are combined with the production results of the programming model to estimate the number of commercial farms required for each of the seven alternatives. This procedure is described more completely in Appendix C. The 1.7 million farms estimated under Alternative A are 112,300 less than were in operation in 1972. Net income per farm for this alternative, $12,193, is $1,094 more in 1972 and $2,307 more than the 1969-72 average.

As crop production is expanded under Alternative B, cash receipts from crops increase because of the additional volume of production required and the higher per unit supply price estimated for the crop commodities. Livestock production decreases but price increases offset the production decline and receipts from livestock also increase under Alternative B. Total cash receipts under Alternative B, $83.0 billion, are $14.1 billion greater than under Alternative A. Increases in production expenses reduce the increase in net receipts to $12.4 billion between the two cases. When translated to a per farm basis, expanded exports result in a $5,372 increase in net income.

Alternatives B and C differ only in that the former incorporates the typical-farm structure while the latter incorporates the medium-farm structure. Only slight differences result between the two situations for the income variables in Table 23. The largest difference is in net income per farm which is $2,865 greater for Alternative B. Lower per farm income is estimated under Alternative C because the medium-farm structure implies a slightly smaller average farm size and therefore more farming operations than does the typical-farm structure.

The large-farm structure is incorporated within Alternative D. Cash receipts under this alternative decrease from their level under Alternative B because of the lower supply prices for crops estimated for this alternative. Production expenses also decrease, by almost $5.4 billion dollars, between these two cases. (The procedures described in Appendix B assume the scale economies computed in the programming model for wheat, feed grains, soybeans, and cotton are relevant for other agricultural commodities.) Since production expenses fall by more than do cash receipts under Alternative D, total net farm income for this alternative is $1.4 billion, or 4 percent, more than for Alternative B. However, only 1.1 million farms are required for this alternative.

This drastic reduction in farm numbers results in a greatly expanded per farm net income. Net income per farm under this alternative, $32,484, is $14,919 greater than for Alternative B and $20,291 more than for Alternative A.

Alternative E is designed to represent a maximum efficiency scenario for American agriculture and is the only alternative in the analysis not incorporating the 50 percent resource mobility restraints. Without these restraints, the programming model can select the most efficient production pattern without regard to any restraints on resource mobility resulting from previous production patterns. Both cash receipts and production expenses are less under Alternative E than for either Alternatives B or D. Since cash receipts decrease by slightly more than production expenses, net income to the farming sector is slightly lower than for the other two cases. Under Alternative E net income per farm, $30,128, is much greater than for Alternative B and only slightly less than under Alternative D.

Alternatives F and G compare two possible methods of implementing a government farm program designed to attain a specified farm price for wheat, feed grains, and cotton lint. Alternative G incorporates acreage quotas to insure that the supply prices of that model equal the prescribed levels but Alternative F operates as if a free market exists and deficiency payments are made to raise market prices to the set level. Cash receipts under Alternative G, $70.8 billion, are $2.2 billion higher than under Alternative F because of the lower market prices of the latter case. Production expenses are nearly equal for these two cases as the more inefficient production pattern of Alternative G is offset by the greater volume of production associated with Alternative F. Estimated net returns to the farming sector for these two alternatives differ by $2.2 billion.

In both cases, government payments would be made to the agricultural industry. For Alternative F, an estimated $812.5 million would be needed as a deficiency payments. For Alternative G, it was assumed that payments would be needed to induce farmers not to produce on certain acres. The average per acre return estimated in the programming model was incorporated as the payment needed to induce farmers to withdraw land from production. This payment amounted to $687 million for the entire sector. With these payments, total net farm income under Alternative G is $2.1 billion greater than under Alternative F. On a per farm basis, net income under Alternative F, $10,667, is $1,098 less than for Alternative G.

Consumer Food Costs

As evidenced by the recent consumer dissatisfaction with rising food costs, changes in the agricultural industry which affect the price of food are of extreme concern to American consumers. Recognizing this concern, three estimates of consumer food costs are made in this analysis. These estimates relate to the three different quantities of livestock products discussed in the demands section of Chapter III.[1] Table 24 presents these estimates as well as actual data for recent periods.

Estimated consumer expenditures under Alternatives A and F are sharply higher than in 1972. Both on a total and a per capita basis, expenditures for these situations are well above 1972 levels. Total expenditures, $171.6 billion, would be 48 percent above 1972 while per capita expenditures are 33 percent greater, with most of the increase being concentrated in the meat products and other categories.

When exports are expanded as for Alternatives B, C, D, and E; the resulting higher prices for livestock feed are translated into higher food costs for the American consumer. Expenditure estimates for the expanded export case are $4.9 billion greater than for Alternative A. On a per capita basis, this amounts to $21 per person.

The higher feed expenditures estimated for Alternative G reflect the production inefficiencies of the acreage quotas of

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[1]Consumer expenditures for meat products, poultry and eggs, and dairy products are estimated directly from the quantity and price data used in the demand section of the analysis. Equations to estimate expenditures for the four products in the other category are from Heady and Sonka (15).

Table 24. Estimates of total and per capita consumer food expenditures for each model alternative with 1969-72 average and 1972 expenditures for comparison

	1969-72 average[a]	1972[a]	Model alternatives A,F	B,C,D,E	G
		(Million dollars)[b]			
Meat products	31,944.5	35,256	59,083.4	63,411.2	60,241.3
Poultry and eggs	8,149.3	8,137	8,835.2	9,390.8	8,980.7
Dairy products	16,458.0	17,551	16,810.1	16,810.1	16,810.1
Other[c]	56,374.3	55,263	86,852.9	86,852.9	86,852.9
All products	107,926.0	116,207	171,581.6	176,465.0	172,885.0
Per capita costs (dollars)[b]	524	557	740	761	745

[a]Source: (50,52).

[b]All values for 1980 are measured in 1972 dollars with no adjustment for inflation to 1980.

[c]Includes bakery products, fruits and vegetables, miscellaneous items and grain mill products.

that alternative. Compared to Alternative F, estimated food expenditures are $1.3 billion, or $5 per person, more because of those acreage quotas.

Input Requirements

Each of the seven model alternatives requires a different quantity and mix of productive inputs to attain its desired level of production. Both the quantity of inputs required and the combination in which they are used have impacts on the farming industry and on the suppliers of these inputs. Tables 25 and 26 present the estimated value of purchased inputs and the estimated hours of labor, respectively, required for each of the model alternatives. In addition, Tables 42-46 present data on estimated values for five input categories; labor, machinery and equipment, fertilizer, seed, and miscellaneous items.

The demand for inputs jumps sharply as exports are expanded and as additional acres are brought into production. Nationally, the value of purchased inputs would increase by 9 percent and labor requirements would be 11 percent greater under Alternative B than under Alternative A. For purchased inputs, the largest differences between Alternatives A and B occur in the Appalachian region, 35 percent, the Southeast region; 52 percent, and the Northern Plains region; 22 percent. These same regions would have 51, 63, and 22 percent increases,

Table 25. Value of purchased inputs required to produce the endogenous crops for each of model alternatives on a national and a farm production region basis

Region	Model alternatives						
	A	B	C	D	E	F	G
	(Thousand dollars)						
United States	13,357,400	14,537,584	14,539,807	12,605,446	12,211,616	13,357,137	13,527,657
Northeast	367,524	363,679	365,665	292,056	296,322	369,676	347,392
Corn Belt	4,678,730	4,629,904	4,615,592	4,140,823	4,149,408	4,653,171	4,706,171
Lake States	1,215,462	1,255,632	1,207,329	1,030,600	1,016,683	1,172,023	1,197,186
Appalachian	573,693	774,432	765,829	663,862	632,261	401,261	612,431
Southeast	562,663	853,076	903,729	729,708	633,400	644,780	657,270
Delta States	743,435	820,321	918,046	746,544	597,255	847,519	910,964
Southern Plains	1,623,171	1,680,720	1,662,074	1,390,795	1,350,220	1,635,453	1,692,586
Northern Plains	2,409,427	2,928,327	2,840,128	2,478,828	2,359,090	2,367,295	2,471,151
Mountain	682,107	730,305	767,724	650,617	638,928	675,596	581,711
Pacific	501,188	501,188	493,691	481,613	538,049	490,363	350,795

Table 26. Hours of labor required to produce the endogenous crops for each of the model alternatives on a national and a farm production region basis

Region	Model alternatives						
	A	B	C	D	E	F	G
	(Thousand hours)						
United States	1,404,764	1,555,321	1,486,304	1,293,177	1,264,375	1,357,162	1,334,149
Northeast	30,605	30,416	33,614	30,102	30,682	33,812	31,139
Corn Belt	462,221	466,385	448,291	418,352	420,784	449,607	449,080
Lake States	143,779	152,271	151,527	137,869	135,852	144,605	151,069
Appalachian	62,352	94,109	55,220	49,459	56,193	39,371	47,310
Southeast	55,983	91,108	93,787	52,519	44,177	60,337	50,813
Delta States	101,022	110,231	85,063	74,238	55,185	76,222	84,559
Southern Plains	214,025	226,630	226,048	199,203	200,479	221,855	204,518
Northern Plains	205,761	250,184	258,587	209,424	194,050	210,961	218,066
Mountain	76,697	81,668	83,415	73,708	72,766	70,244	63,414
Pacific	52,319	52,319	50,752	48,303	54,207	50,148	34,181

respectively, in the hours of labor required under Alternative B.

Alternatives B and C differ only in that the former incorporates the typical-farm structure and the latter incorporates the medium-farm structure. Nationally, the former alternative is estimated to be slightly more labor intensive as it would require 5 percent more labor than Alternative C. Both situations would have nearly equal purchased input requirements.

Alternative B is estimated to require 15 more purchased inputs and 20 more labor than under Alternative D. Since the demand quantities are equal for these two situations, this input reduction results from scale economics associated with the larger producing units of Alternative D. The relatively greater reduction in labor usage between the two situations indicates that Alternative D with its large-scale operations is relatively more capital intensive than Alternative B.

If resources were to become completely mobile between crops and between geographic areas, as in Alternative E, shifts in the location of demand for production inputs would occur. Compared to Alternative D, significant reductions in input usage are estimated for the Southeast and Delta States regions under Alternative E. Labor and purchased inputs requirements decrease by 16 and 13 percent, respectively, for the Southeast region and by 26 and 20 percent, respectively, for the Delta States regions. A sizeable increase in input usage, however, is estimated for the Pacific region. A 403,600 acre increase in cotton acreage between Alternatives D and E leads to a 12 percent increase both in the requirement for purchased inputs and in labor usage in this region under Alternative E.

Nationally, the estimated value of purchased inputs required for Alternative G is slightly higher than for Alternative F. Labor usage, however, would be slightly lower under Alternative G. These relatively similar national input requirements occur even though more production is specified for Alternative F than for Alternative G. The Appalachian and Delta States regions would have sizeably higher input requirements under Alternative G than under Alternative F. Conversely, as cotton production shifts out of the Mountain and Pacific regions under Alternative G, significant reductions in input usage result.

Soil-Loss Impacts

As additional acres are brought into production, greater stress is placed on the land and water resources of rural America. Since much public concern has recently been directed towards environmental issues, estimates of gross soil-loss are calculated for each of the model situations.[1] These estimates, expressed in index form, are reported in Table 27 for the nation and the ten farm production regions. These index values are calculated so that the soil-loss estimate under Alternative A is equal to 100 for each region and the values for the other alternatives represent the percentage change from Alternative A.

Nationally, the additional exports of Alternative B result in an estimated 11 percent increase in gross soil-loss over that estimated for Alternative A. The impact of the higher export levels on soil erosion varies greatly among the ten farm production regions. In the Northeast and Pacific regions, the model's land base is fully utilized under Alternative A. Therefore, increasing national exports and production has no soil-loss effect in these regions. In contrast, very large increases in soil-loss are estimated for the Appalachian, Southeast and Northern Plains regions. Gross soil-loss estimates for these regions would be 37, 44, and 18 percent higher, respectively, under Alternative B. These sharp increases in soil-loss and the resulting deterioration of water quality represent an additional cost of agricultural exports to residents of these regions. Soil-loss estimates in the

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[1]These estimates are the product of the acreage requirements of the programming solutions and regional per acre soil-loss estimates from a study done previously at Iowa State University (29).

Table 27. Estimates of soil-loss on a national and on a farm production region basis for each of the model alternatives[a]

Region	Model alternatives						
	A	B	C	D	E	F	G
United States	100	111	111	111	109	100	101
Northeast	100	100	100	100	100	100	100
Corn Belt	100	102	102	102	102	102	102
Lake States	100	102	102	102	102	100	100
Appalachian	100	137	137	137	128	88	100
Southeast	100	144	148	148	144	107	111
Delta States	100	112	112	112	110	102	98
Southern Plains	100	104	104	104	104	103	99
Northern Plains	100	118	118	118	115	100	106
Mountain	100	108	108	108	102	98	89
Pacific	100	100	100	100	100	100	82

[a]Expressed as an index value with the soil-loss estimate under Alternative A = 100 for each region.

remaining five farm production regions are also higher under Alternative B than under Alternative A but by no more than 10 percent. Since the model's land base is nearly fully utilized under each of the maximum export alternatives (Alternatives B, C, D and E), the national and regional soil-loss estimates for these alternatives are very similar, with only slight decreases noted for Alternative E.

Production patterns do not vary greatly between Alternatives F and G because of the similar estimated demands for these two situations. Therefore the national and most of the regional soil-loss estimates are nearly equal for these two situations. The acreage quotas associated with Alternative G force increases in harvested acreage in the Appalachian, Southeast, and Northern Plains regions (compared to Alternative F) while simultaneously forcing cotton production out of the Mountain and Pacific regions. These acreage shifts result in corresponding changes in the level of soil-loss estimated for these regions.

Secondary Income Generation

Many nonfarm people in the nation are affected by changes in the level of activity or in the structure of the American farming industry. The farm input supplier and output processor are directly affected by changes in the quantity of farm products produced but the impact of these changes does not end with this group. Rural people, including those who work in nonagricultural business occupations, rely on the same services as farmers do. Therefore, if the farm population changes, the availability and cost of these services to other rural inhabitants will also change. In addition, the many backward and forward linkages of a basic industry such as agriculture extend to towns and cities much larger than the traditional rural village. For example, the livelihood of non-rural workers who manufacture farm machinery is also dependent on the level of activity in the farming sector. To provide a basis to examine these impacts, indices are developed which relate the value of production of wheat, feed grains, soybeans, and cotton to the total income generated throughout the nation by the production of these commodities.[1] These secondary income indices are presented in Table 28.

To provide direct comparisons among the seven model alternatives, the income generation outcomes of Alternative A have been normalized to equal 100 and the outcomes of each of the other alternatives are adjusted to reflect the degree of change each represents from that alternative. For example,

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[1]The income generation factors used in this study are defined as follows: the amount by which the total income in the United States economy will increase because of the production of an additional $1 million worth of output in the wheat, feed grains, soybeans, and cotton sectors. The processes used to derive these factors are described in Appendix A.

Table 28. Indices comparing the amount of income generated by the four endogenous crop commodities under Alternative A with the amount of income generated under each of the other model alternatives in the nation and in the ten farm production regions

Region	Model alternatives						
	A	B	C	D	E	F	G
United States	100	156	152	131	109	98	105
Northeast	100	138	137	121	106	99	100
Corn Belt	100	149	146	127	108	98	105
Lake States	100	155	153	132	109	98	106
Appalachian	100	179	166	151	129	87	109
Southeast	100	188	198	162	119	111	113
Delta States	100	144	144	126	83	101	112
Southern Plains	100	155	141	123	101	99	109
Northern Plains	100	177	172	148	120	98	109
Mountain	100	143	140	120	101	91	90
Pacific	100	132	134	107	106	102	78

the national index value of 156 for Alternative B refers to a 56 percent increase in the total income generated by the four commodities endogenous to the programming model. (This does not refer to the total income being generated in the U.S. economy but rather only that income generated by the endogenous crops.) The large increase in income generation estimated at the national level for Alternative B is repeated for each of the ten farm production regions. Those farm production regions in which secondary income index values increase by the greatest percentage under Alternative B are those that have the most significant change in production compared to the Alternative A (i.e., the Appalachian, Northern Plains and Southeast regions).

Both Alternatives B and D incorporate the maximum export assumption but the typical-farm structure is associated with the former alternative and the large-farm structure is associated with the latter. The 16 percent decrease in income generation estimated for Alternative D results from the lower farm prices of this alternative and, in addition, reflects the lesser quantity of inputs required by the large-farm structure. For each of the farm production regions approximately the same differential exists between these alternatives as is noted at the national level.

Comparison of Alternatives D and E reflect the impact of resource mobility restraints on secondary income generation.

As production is concentrated in areas which use less resources, the estimated secondary income effect in those regions which lose production also declines. Nationally, a 17 percent decrease occurs between Alternatives D and E. Regionally, the most drastic reduction results in the Southeast and Delta States regions which both would produce much less cotton under Alternative E than under Alternative D.

The national income index values estimated for Alternatives A, F, and G are very similar as are most of the regional values for these three alternatives.[1] The Pacific region is the only region which would have a markedly lower income index value under Alternative G than under Alternative F. This region would have a sizeable decrease in cotton and wheat production under this alternative as compared to Alternative F. The reduction in income generation noted for the Pacific region results even though the market prices of Alternative G are higher than those of Alternative F.

Because we relate value of output to secondary income generation, supply control programs, such as in Alternative G, may be estimated to have positive secondary income effects even though they act to reduce farm output. Any reduction in

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[1]Farm income from either direct price support or acreage diversion payments is not included in the value of farm output estimates for Alternatives F and G. It is assumed that these payments reflect income transfers within the nation rather than income generation.

farm output, however, is not likely to have positive effects on a small rural community whose main source of employment is processing farm output or supplying farm inputs. But, the additional farm income associated with a supply control program will generate economic activity in larger rural towns serving as trade centers for the farming industry. Despite the possible positive income effects, it should be emphasized that supply control type programs may have negative, rather than positive effects, for the small rural village more dependent on the quantity of farm output produced than on the value of that output.

CHAPTER VI. SUMMARY

The primary goal of this analysis is to develop an interregional linear programming model of the wheat, feed grains, soybeans, and cotton sectors of American agriculture and to compare the results of this programming model for alternative future situations. Seven distinct situations, called model alternatives, are defined in the report (see Table 8). These seven alternatives bracket a variety of circumstances and form a set of contrasts relating to the future of American agriculture. These seven alternatives are formed by altering three basic parameters; the level of agricultural exports, the farm-size structure existing in American agriculture, and the method of implementing a government farm program designed to attain a certain price level for wheat, feed grains, and cotton lint.

One contrast derivable from the analysis compares the past output levels of American agriculture with its condition in 1980, if the trend in export levels and the structure of agriculture continue as it has in the recent past. This contrast is obtained by comparing the estimated results under Alternative A with recent data. If, however, we assume that all of the production of the four crop commodities in excess of domestic demand can be readily exported, a different set of outcomes will result. The direct impact of these higher exports is shown between the results of Alternatives B and A.

The farm-size structure existing in American agriculture is the only parameter that varies among Alternatives B, C, and D. For Alternative D, it is assumed that all farms would be of the type and scale of those farms in Class I, gross sales of more than $40,000, of the Bureau of the Census. Farms would all be of a medium size, gross sales of from $10,000 to $39,999, in Alternative C. For Alternative B, a mixture of small-, medium-, and large-scale farms is assumed to exist. This mixture is based on the historic trend in the average size of farm. The assumption of maximum production is incorporated in each of these situations.

For six of the seven model alternatives, restraints are imposed on the degree of resource mobility allowed in the model. The restraints are tied to the 1969 distribution of production, thereby forcing the location of production in the future to be affected by its part distribution. In one situation, Alternative E, these mobility restraints are removed to indicate the theoretically most efficient production distribution available in the programming model. This alternative incorporates the large-farm structure and is directly comparable to Alternative D.

Alternatives F and G investigate two possible implementations of a government farm policy designed to achieve a certain level of farm prices for wheat, feed grains, and cotton lint. For Alternative F, the market is allowed to determine a price based on the supply and demand for these agricultural products. If the resulting market prices in this case are less than the socially-desired prices, direct subsidies would be made to farmers to attain the desired levels. For Alternative G, acreage quotas based on historic acreage allotments are imposed to force the market prices of this case to be exactly equal the desired prices. The target prices of the 1973 Agricultural and Consumer Protection Act represent socially-desired prices in both alternatives. Also, both alternatives incorporate the medium-farm structure to indicate the maximum number of farms (with adequate per farm incomes) possible in each case.

The contrast and comparisons just discussed are examined by estimating the value of key farm and nonfarm variables for each of the seven alternatives. Variables directly related to farming include; the price of farm commodities, location and quantity of production, the agricultural demand for inputs, the number of commercial farms, and net farm income. In addition estimates of consumer food costs, changes in the level of gross soil-loss, and changes in the amount of income generated by the production of certain agricultural commodities are also included. Examination of the value of these variables provides an indication of possible trade-offs between farm and nonfarm groups.

Compared to 1972 levels, a sharp increase in the production of feed grains and soybeans is required under Alternative A. However, estimated wheat production, 1.6 million bushels, is only 69 million bushels greater than in 1972 and the estimated production of cotton lint, 11.5 million bales, is less than in 1972 but still greater than the 1969-72 average production. Even though the model yields are higher than in 1972, 26.5 million additional acres are required for Alternative A. This is an increase of 13 percent over the 200.2 million acres harvested in 1972. The location of these additional acres would be concentrated in the Northeast, Corn Belt, Lake States, Southern Plains, Northern Plains, and Mountain Regions.

For Alternative A, wheat and feed grain prices are slightly higher than in 1972 while cotton lint prices would jump sharply. Because of large increases in the acreage devoted to soybeans, the estimated price of soybeans falls well below recent price levels. These production and price data are translated into income figures for the farming sector. Total net farm income for this alternative is estimated to be greater than in 1972 even though no government farm payments are included in the 1980 estimate. Over $3.9 million was paid to the farming sector for this source in 1972. Since the number of commercial farms is estimated to decrease by 112,300 farms, per farm net income under Alternative A, $12,193, is $1,094 greater than in 1972. Consumer food costs are projected to increase sharply over 1972 levels for this situation. On a per capita basis, the model estimate of $740 is 33 percent greater than in 1972.

A 25 percent increase in exports of each of the four commodities comprises the only difference between Alternatives A and B. Since exports are a major portion of the total demand for wheat and soybeans, the largest gains in production would occur for these two commodities. Production to satisfy the additional export demand requires 22.7 million more acres than estimated for Alternative A. These acres would be concentrated in the Appalachian, Southeast, and Northern Plains regions.

As production shifts to more marginal, higher-cost areas, the price necessary to cover production costs also must rise. Compared to Alternative A, estimated supply prices under Alternative B increase by 81 cents per bushel for wheat, 62 cents per bushel for feed grains, $1.82 per bushel for soybeans, and 3.2 cents per pounds for cotton lint. These price increases are translated into a $12.4 billion increase in income to the farm sector. On a per farm basis, net income under Alternative B, $17,565, is $5,372 more than for Alternative A and $6,466 more than in 1972. Consumer food costs for this case are estimated to increase by $21 per person even though the higher prices of this alternative cause its consumption of meat products to be lower than under Alternative A.

As more acres are brought into production to satisfy the higher export demands, more pressure is applied to the soil and water resources of the nation. Reflecting this pressure the national soil-loss estimate under Alternative B is estimated to increase by 11 percent over Alternative A. The Appalachian and Southeast regions would have especially large increases because they have relatively large increases in production and their land base is relatively more susceptible to erosion.

As price and production increase, the farm and off-farm income generated by these four crop commodities also jumps. Nationally, the income generated by these crops would increase by 56 percent over that generated under Alternative A. While all regions share in this increase, the relatively greatest increases are concentrated in the Appalachian, Southeast, and Northern Plains regions.

Alternatives B, C, and D provide a comparison of the performance of the agricultural industry under three specifications as to the size and scale of the individual farming operations which form the industry. Alternative B incorporates the typical-farm structure, Alternative C the medium-farm structure, and Alternative D the large-farm structure. Alternatives B and C contain fairly similar results for most of the variables discussed in the analysis. Since the medium-farm structure implies a slightly smaller average farm size, 334,800 more farms are required in this case than for Alternative B.

This leads to a $2,865 reduction in net income per farm for Alternative C. However, the similarity of the estimates for these two alternatives does support the hypothesis that the farming industry could provide these four crop commodities equally well whether composed of farms all of moderate size or composed of a mixture of farm sizes.

Since the demand for agricultural products is held constant for Alternatives B and D, comparison of these two situations indicates potential efficiencies of production if all farms were of the larger type incorporated in Alternative D. These efficiencies are illustrated by the lower supply prices required for this alternative. Per unit reductions are estimated at 33 cents for wheat, 28 cents for feed grains, 74 cents for soybeans, and 6.9 cents for cotton lint. Savings in the quantity of inputs required are evidenced by reductions in both the usage of labor and of purchased inputs. Alternative D would require 17 percent fewer hours of labor and a 13 percent reduction in the value of purchased inputs while producing the same quantity of the four crops as does Alternative B.

The larger size farming operation assumed for Alternative D results in a reduction of 827,900 farming units (compared to Alternative B). This is translated into a massive jump in per farm net income between the two cases. Net income per farm under Alternative D, $32,484, is $14,919 greater than in the typical-farm case. While this represents a positive effect for those farmers remaining in operation, the dual effect of fewer farmers and reduced input usage would not be beneficial to the rural communities serving agriculture. The income generated by the production of these four crop commodities in the large-farm case would be only 84 percent of that estimated for Alternative B.

If resource mobility restraints are removed, as for Alternative E, 5.2 million acres that would be needed under Alternative D would no longer be required. The bulk of these acres would be located in the Northern Plains regions. Since these higher cost areas would not be utilized and because each area would concentrate on those crops most profitable for it, the supply prices of the four commodities are estimated to be lower in this case than under Alternative D. Per unit, the supply price estimated for this circumstance is reduced by 55 cents for wheat, 25 cents for feed grains, 67 cents for soybeans, and 6.9 cents for cotton lint from those estimated for Alternative D.

Both the estimated hours of labor and the value of purchased inputs would be less in the situation without the resource mobility restraints than for Alternative D even though both situations incorporate the same farm-size structure and demand levels. This reduction in input usage, as well as the lower supply prices noted for Alternative E, lead to a significant reduction in the amount of income generated by the four crop commodities. The income generation index for this alternative is estimated at an index value of 109 or 83 percent of its level under Alternative D.

While Alternatives F and G incorporate the same set of export demands, domestic demands are slightly lower for the latter case. These lower demands are specified because the higher market prices of the feed commodities lead to higher livestock prices and, therefore, a slight reduction in livestock consumption under Alternative G. Despite its slightly reduced demand requirement, this alternative would require 1.6 million more acres than would Alternative F. The more inefficient production patterns associated with the acreage quotas of Alternative G are the cause of this expanded acreage requirement.

The market prices of wheat, feed grains, and cotton lint under Alternative G are forced to equal the target prices of the 1973 Agricultural and Consumer Protection Act. These prices are somewhat higher than the supply prices of Alternative F. On a per unit basis, these increases are estimated at 26 cents for wheat, 3 cents for feed grains, 22 cents for soybeans, and 5 cents for cotton lint. No acreage quotas are imposed for soybeans under Alternative G but a higher price results because of the acreage quotas associated with the other commodities.

As specified here, both alternatives would require a payment from government sources. For Alternative F, an $812.5 million deficiency payment is needed to raise the market-determined prices to target price levels. For Alternative G, a $687 million payment is estimated to insure that the necessary acres remain out of production so that the market prices equal the desired levels. With these government payments, net income to the farming sector is slightly higher for Alternative G than for Alternative F. Per farm net income for Alternative G, $11,765, is $1,098 greater than for Alternative F.

The higher market prices associated with Alternative G lead to a slightly higher estimate of consumer food costs for this case than for Alternative F. Food costs are estimated to be $1.3 billion higher in the former situation.

BIBLIOGRAPHY

1. Barlowe, Raleigh. Land Resource Economics. 2nd ed. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1972.

2. Bentley, Orville G. "National Outlook and Perspective." In Rural Development Research Priorities, pp. 1-8. Edited by Larry R. Whiting. Ames: Iowa State University Press. 1973.

3. Boudeville, J-R. Problems of Regional Economic Planning. Chicago: Aldine Publishing Company, 1966.

4. Egbert, Alvin Charles. "Programming Regional Adjustments in Resource Use for Grain Production." Ph.D. dissertation, Iowa State University, 1958.

5. Eldridge, Eber. "Trends Related to Rural Areas." Rural Community Development Seminar: Focus on Iowa. Center for Agricultural and Rural Development, Iowa State University of Science and Technology, May 1972 (Seminar Papers).

6. Eyvindson, Roger Karton. "A Model of Interregional Competition in Agriculture Incorporating Consuming Regions, Producing Areas, Farm Size Groups and Land Classes." Volume I through V. Ph.D. dissertation. Iowa State University of Science and Technology, 1970.

7. Ferguson, C. E. Microeconomic Theory. 3rd ed. Homewood, Illinois: Richard D. Irwin, Inc., 1972.

8. Hadwigger, Don F. Federal Wheat Commodity Programs. Ames, Iowa: The Iowa State University Press, 1970.

9. Hathaway, Dale E. Government and Agriculture: Public Policy in a Democratic Society. New York: The Macmillan Company, 1963.

10. Heady, Earl O. Economics of Agricultural Production and Resource Use. Englewood Cliffs, New Jersey: Prentice-Hall, Inc. 1952.

11. Heady, Earl O. and Wilfred Chandler. Linear Programming Methods. Ames, Iowa: The Iowa State University Press, 1958.

12. Heady, Earl O. and John L. Dillon. Agricultural Production Functions. Ames, Iowa: The Iowa State University Press, 1961.

13. Heady, Earl O. and Leo V. Mayer. Food Needs and U.S. Agriculture in 1980. National Advisory Commission on Food and Fiber, Washington, D.C., Technical Papers Volume 1, August 1967.

14. Heady, Earl O. and Steven T. Sonka. "Farm Size, Rural Community Income and Consumer Welfare." American Journal of Agricultural Economics (Forthcoming).

15. Heady, Earl O. and Steven T. Sonka. Income and Employment Generation in Rural Areas in Relation to Alternative Farm Programs with Special Emphasis on the North Central Region. North Central Regional Center for Rural Development, Iowa State University of Science and Technology, December 1973.

16. Heady, Earl O.; Howard C. Madsen; Kenneth J. Nicol; and Stanley H. Hargrove. Agricultural Water Policies and the Environment. Center for Agricultural and Rural Development, Iowa State University of Science and Technology, CARD Report 40T, June 1972.

17. Heinz, John P. "The Political Impasse in Farm Support Legislation." In Interest Group Politics in America, pp. 186-198. Edited by Robert H. Salisbury. New York: Harper & Row, Publishers, 1970.

18. Henderson, James M. and Richard E. Quandt. Microeconomic Theory. 2nd ed. New York: McGraw-Hill Book Company, 1971.

19. Ibach, D. B. and T. W. Adams. Crop Yield Responses to Fertilizer in the United States. Economic Research Service and Statistical Reporting Service Statistical Bulletin No. 431, August 1968.

20. Kaldor, Don. "Rural Industrialization: A Policy Instrument for Rural Development." Rural Community Development Seminar: Focus on Iowa. Center for Agricultural and Rural Development, Iowa State University of Science and Technology, May 1972 (Seminar Papers).

21. Koo, Won Whe. "Linear Programming Models Applied to Interregional Competition of Grain Transportation and Production." Ph.D. dissertation, Iowa State University of Science and Technology, 1974.

22. Madsen, Howard C. and Earl O. Heady. Bargaining Power Programs: Estimated Effects on Production, Net Farm Incomes and Food Costs for Specified Price Levels. Center for Agricultural and Rural Development, Iowa State University of Science and Technology, CARD Report 39, September 1971.

23. Martin, William E. and Harold O. Carter. A California Interindustry Analysis Emphasizing Agriculture, Parts 1 and 2. California Agricultural Experiment Station, Giannini Foundation Research Report No. 250, February 1962.

24. Mayer, Leo V. "Delineation of Iowa Communities with Major Economic Attachment to Agriculture." Rural Community Development Seminar: Focus on Iowa. Center for Agricultural and Rural Development, Iowa State University of Science and Technology, May 1972 (Seminar Papers).

25. Miernyk, William H. The Elements of Input-Output Analysis. New York: Random House, 1965.

26. New York Times. 27 November 1930. p. 47.

27. New York Times. 10 August 1972. p. 1.

28. New York Times. 15 March 1973. p. 68.

29. Nicol, Kenneth J. "A Modelling Approach to the Economic and Regional Impacts of Sediment Loss Control." Ph.D. dissertation, Iowa State University of Science and Technology, 1974.

30. The Northwestern Miller. Minneapolis: Miller Publishing Company, 1971.

31. Quance, Leroy and Luther G. Tweeten. "Policies, 1930-1970." In Size, Structure, and Future of Farms, pp. 19-39. Edited by A. Gordon Ball and Earl O. Heady. Ames, Iowa: The Iowa State University Press, 1972.

32. Rasmussen, Wayne D. and Gladys L. Baker. A Short History of Price Support and Adjustment Legislation and Programs for Agriculture, 1933-65. Economic Research Service, Agricultural Economic Research Report Volume 18, July 1966.

33. Ray, Daryll Eugene. "An Econometric Simulation Model of United States Agriculture with Commodity Submodels." Ph.D. dissertation, Iowa State University of Science and Technology, 1971.

34. Schluter, Gerald Emil. "An Estimation of Agricultural Employment Through an Input-Output Study." Ph.D. dissertation, Iowa State University of Science and Technology, 1971.

35. Schultz, Theodore W. "Changes in Economic Structure Affecting American Agriculture." Journal of Farm Economics 28 (February 1946): 444-457.

36. Shepherd, Geoffrey S. Farm Policy: New Directions. Ames, Iowa: The Iowa State University Press, 1964.

37. Skold, Melvin Den. "Programming Regional Adjustments in Grain Production to Meet Changing Demands." Ph.D. dissertation, Iowa State University of Science and Technology, 1963.

38. Sonka, Steven T. and Earl O. Heady. American Farm-Size Structure in Relation to Income and Employment Opportunities of Farms, Rural Communities and Other Sectors. Center for Agricultural and Rural Development, Iowa State University of Science and Technology, CARD Report 48, June 1974.

39. Stoecker, Arthur. "A Quadratic Programming Model of U.S. Agriculture in 1980: Theory and Application." Ph.D. dissertation, Iowa State University of Science and Technology, 1974.

40. Talbot, Ross B. and Don F. Hadwigger. The Policy Process in American Agriculture. San Francisco: Chandler Publishing Company, 1968.

41. Tefertiller, Kenneth R. "Rural Development in an Urban Age." American Journal of Agricultural Economics 55 (December 1973): 771-777.

42. U.S. Department of Agriculture. Agricultural Statistics, 1972. Washington, D.C.: USDA, 1972.

43. U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service. "The Agricultural and Consumer Protection Act of 1973." Washington, D.C., 1973. (Mimeographed.)

44. U.S. Department of Agriculture, Consumer and Marketing Service. Grain Market News (Independence, Missouri) 18, (3) (January 16, 1970).

45. U.S. Department of Agriculture, Consumer and Marketing Service. Grain Market News (Independence, Missouri) 19, (3) (January 22, 1971).

46. U.S. Department of Agriculture, Consumer and Marketing Service. Grain Market News (Independence, Missouri) 20, (3) (January 21, 1972).

47. U.S. Department of Agriculture, Consumer and Marketing Service. Grain Market News (Independence, Missouri) 21, (3) (January 19, 1973).

48. U.S. Department of Agriculture, Economic Research Service. Cattle Raising in the United States. U.S.D.A.-E.R.S. Agricultural Economic Report 235, January 1973.

49. U.S. Department of Agriculture, Economic Research Service. Consumption of Feed by Livestock 1940-59. U.S.D.A.-E.R.S. Production Research Report 79, March 1964.

50. U.S. Department of Agriculture, Economic Research Service. Farm Income Situation FIS-222, July 1973.

51. U.S. Department of Agriculture, Economic Research Service. Food Consumption, Prices, and Expenditures. U.S.D.A.-E.R.S. Agricultural Economic Report No. 138, January 1972. (Supplement.)

52. U.S. Department of Agriculture, Economic Research Service. Marketing and Transportation Situation MTS-190, August 1973.

53. U.S. Department of Agriculture, Economic Research Service. National and State Livestock-Feed Relationships. U.S.D.A.-E.R.S. Supplement for 1972 to Statistical Bulletin 446, July 1972.

54. U.S. Department of Agriculture, Economic Research Service. National Food Situation NFS-146, November 1973.

55. U.S. Department of Agriculture, Economic Research Service. Selected U.S. Crop Budgets: Yields, Inputs and Variable Costs, Volume III, Great Plains Region. U.S.D.A.-E.R.S. 459, 1971.

56. U.S. Department of Agriculture, Economic Research Service. U.S. Fats and Oils Statistics, 1950-71. U.S.D.A.-E.R.S. Statistical Bulletin 489, July 1972.

57. U.S. Department of Agriculture, Outlook and Situation Board. Agricultural Supply and Demand Estimates. U.S.D.A., No. 8, January 1974.

58. U.S. Department of Agriculture, Economic Research, Statistical Reporting, Agricultural Research and Foreign Agricultural Services. 1971 Handbook of Agricultural Charts. Washington, D.C.: Agricultural Handbook No. 423, November 1971.

59. U.S. Department of Agriculture, Statistical Reporting Service. Agricultural Prices Annual Summary 1972. U.S.D.A., Pr 1-3 (74), June 1973.

60. U.S. Department of Agriculture, Statistical Reporting Service. Agricultural Prices Annual Summary 1973. U.S.D.A., Pr 1-3 (74), June 1974.

61. U.S. Department of Agriculture, Statistical Reporting Service. Crop Production 1971 Annual Summary. U.S.D.A., CrPr 2-1, (72), January 14, 1972.

62. U.S. Department of Agriculture, Statistical Reporting Service. Crop Production 1972 Annual Summary. U.S.D.A., CrPr 2-1, (73), January 1973.

63. U.S. Department of Agriculture, Statistical Reporting Service. Crop Production 1973 Annual Summary. U.S.D.A., CrPr 2-1 (74), January 16, 1974.

64. U.S. Department of Commerce, Bureau of Economic Analysis. The Economic Base of Selected Geographic Areas, Historical and Projected 1929 to 2020. Preliminary Report to the Water Resources Council, Washington, D.C., 1968.

65. U.S. Department of Commerce, Bureau of the Census. 1967 Census of Manufacturers, Volume II, Industry Statistics. Washington, D.C., 1971.

66. U.S. Department of Commerce, Bureau of the Census. Population Estimates and Projections. Washington, D.C., Current Population Reports Series No. 477, March 1972.

67. U.S. Department of Commerce, Bureau of the Census. Statistical Abstract of the United States 1971. 92nd ed. Washington, D.C., 1971.

68. U.S. Department of Commerce, Bureau of the Census. Statistical Abstract of the United States 1972. 93rd ed. Washington, D.C., 1972.

69. U.S. Department of Commerce, Bureau of the Census. U.S. Census of Agriculture, 1960, Volume I, Counties and State Economic Areas. Washington, D.C., October 1962.

70. U.S. Department of Commerce, Bureau of the Census. U.S. Census of Agriculture, 1964, Volume I, Statistics for the States and Counties. Washington, D.C., 1967.

71. U.S. Department of Commerce, Bureau of the Census. U.S. Census of Agriculture, 1969, Volume I, Statistics for the States and Counties. Washington, D.C., 1971.

72. Wadsworth, H. A. "Community Planning and Decision Making to Attract Industry." In Rural Industrialization: Problems and Potentials, pp. 61-67. Edited by Larry R. Whiting. Ames: Iowa State University Press. 1974.

73. Waters, Jerry B. "Scope and National Concerns." In Rural Development Research Priorities, pp. 9-19. Edited by Larry R. Whiting. Ames: Iowa State University Press. 1973.

74. Waugh, Frederick V. Demand and Price Analysis. Economic and Statistical Analysis Division, U.S. Department of Agriculture, Technical Bulletin 1316, November 1964.

75. Webster, Henry H. and A. Edwin Grafton. "Present Potentials for Recreational Development in Iowa." Rural Community Development Seminar: Focus on Iowa. Center for Agricultural and Rural Development, Iowa State University of Science and Technology, May 1972 (Seminar Papers).

76. Whittlesey, Norman Keith. "Linear Programming Models Applied to Interregional Competition and Policy Choices for U.S. Agriculture." Ph.D. dissertation, Iowa State University of Science and Technology, 1964.

APPENDIX A: DEVELOPMENT OF SECONDARY INCOME GENERATION INDICES

One goal of this study is to indicate the total income impacts of the model alternatives. To estimate this effect, income-generation factors are developed which relate the value of production of wheat, feed grains, soybeans, and cotton to the off-farm income that production generates. These income-generation factors are developed using relationships of input-output analysis. While this appendix does not provide a detailed discussion of the theories underlying input-output analysis, it does provide a description of the concepts used to construct the income-generation factors of this study (25, 34).

A transaction table serves as a double-entry ledger of an economy and is the starting point for input-output analysis. Table 29 presents a hypothetical transactions table which will be used throughout the following discussion as an example of the procedures used in this study. To construct the transactions table, each producing sector of the economy (sectors A, B, C, and H in Table 29) is assigned a row and a column in the table. The row assigned to each sector describes the distribution of the output of that sector throughout the economy. The column assigned to each sector shows from what sectors in the economy that sector purchases its inputs. Therefore, every element of the transactions table can be

Table 29. Hypothetical input-output transactions table

Input \ Output		Processing sectors A	B	C	Households (H)	Final demands	Total output
				Dollars			
Processing sectors	A	11	16	30	10	7	74
	B	14	6	9	20	24	73
	C	7	25	14	13	20	79
Households (H)		15	8	20	2	15	60
Payments sector		27	18	6	15	10	76
Total outlay		74	73	79	60	76	362

viewed in two ways. For example, the 16 dollar transaction between sectors A and B (first row, second column: Table 29) can be looked upon either as the sale of part of the output of sector A or as a purchase of inputs by sector B from sector A.

Sector H represents the household sector of the hypothetical economy. In input-output analysis the household sector can be included either as one of the producing sectors or as a part of the final demand sector. In Table 29, households are included as a producing sector; therefore, consumption purchases are regarded as inputs to the production process of the household sector and labor is the output of the household sector.

The final demand sector in Table 29 corresponds to autonomous demand for the output of the producing sectors. It includes such things as inventory accumulation, exports from the economy, government purchases, and other exogenous demands. The final payments sector in Table 29 introduces the value of the inputs purchased from outside the producing sectors of the economy; including such items as imports, purchases from existing inventory stocks, or depreciation allowances. The final column of Table 29, the total output column, is the summation of value of output sold throughout the economy by each sector and the final row of the table (total outlay) is the total purchases of inputs by each sector. Total output and total outlay must be equal for each producing sector.

The direct requirements table (Table 30) is constructed from the transactions table and presents each transaction in the economy as a proportion of the total outlay of each sector. Each column entry in Table 30 represents the proportion of each dollar's worth of inputs that column sector purchases from the row sector. Therefore, each column contains the production function (in value terms) of that sector. In the example, every dollar of inputs purchased by sector A contains 20.3 cents worth of the output of sector H. The direct requirements table is calculated by dividing each column element by the total output of that column sector after the total output is adjusted for inventory depletion.

Each entry of Table 31, the interdependence table, measures the increase in output of that row sector generated by an additional dollar of sales to final demand by the related column sector. These entries reflect not only the direct and indirect effects of the increased deliveries to final demand but also the induced effects of increased consumer spending by the household sector.[1] In the hypothetical example, the value of output of sector A would increase by

---

[1]The direct effects are given by the direct requirements table (Table 30 in the example). The indirect effects are those increases in output that are due to the additional spending of all the producing sectors in the economy, but not allowing increased consumer expenditures. The induced effects reflect the increased output of each sector caused by increased consumer spending.

Table 30. Hypothetical direct requirements table

		Purchases by sector A	B	C	Households (H)
			(Dollars)		
Production by sector	A	.1486	.2192	.3797	.1667
	B	.1892	.0822	.1139	.3333
	C	.0946	.3425	.1772	.2167
	Households (H)	.2027	.1096	.2532	.0333

Table 31. Hypothetical interdependence table

	A	B	C	Households (H)
		(Dollars)		
A	1.7466	.9829	1.2234	.9143
B	.6595	1.6473	.7971	.8603
C	.6353	.9690	1.9110	.8720
Households (H)	.6074	.6466	.8474	1.5521

98.3 cents for every dollar increase of deliveries to final demand by sector B. Table 31 is formed by subtracting the direct requirements table, Table 30, from an identity matrix and inverting the resulting matrix.

The interdependence coefficients in Table 31 measure the additional output forthcoming from every row sector because of the production of an additional dollar's worth of deliveries to final demand by the respective column sector. To determine the effect of producing an additional dollar's worth of output by any sector, the coefficients in the column of that sector in Table 31 must be adjusted (3). Table 32 presents the adjusted interdependence matrix which is computed by dividing every element in each column by the diagonal element of that column. The coefficients in Table 32 then represent the additional output of each row sector generated by the production of an additional dollar's worth of output by the column sector. For example, sector B produces 37.8 cents worth of output for each dollars worth of output from sector A. The income-generation factor of a dollar's worth of output for any sector can be read directly from the household row of that column sector in Table 32.

The previous discussion can be presented mathematically by the following set of equations. Assume the system under discussion has n processing sectors, m final demand sectors, and d final payments sectors. Let X_i be the output of each of

Table 32. Hypothetical adjusted interdependency table

	A	B	C	Households (H)
		(Dollars)		
A	1.0000	.5967	.6402	.5891
B	.3776	1.0000	.4171	.5543
C	.3637	.5883	1.0000	.5618
Households[a] (H)	.3478	.3926	.4434	1.0000

[a]The income generation factor of each sector is equal to the household row entry for that sector.

the n processing sectors, x_{ij} be the amount of output of sector i used by sector j, and Y_{ik} be the demand for output of sector i by the k-th final demand sector. The following system of equations, A.1, then represents this system:

$$
\begin{array}{lllllll}
X_1 & = x_{11} & + x_{12} & + \ldots + x_{1n} & + Y_{11} & + \ldots + Y_{1m} & \\
X_2 & = x_{21} & + x_{22} & + \ldots + x_{2n} & + Y_{21} & + \ldots + Y_{2m} & \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & (A.1) \\
X_n & = x_{n1} & + x_{n2} & + \ldots + x_{nn} & + Y_{n1} & + \ldots + Y_{n} & \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \\
X_{n+d} & = x_{n+d,1} & + x_{n+d,2} & + \ldots + x_{n+d,n} & + Y_{n+d,1} & + \ldots + Y_{n+d,m} &
\end{array}
$$

Assuming constant technical coefficients for the n processing sectors, net terms can be calculated as in Equation A.2

$$a_{ij} = x_{ij}/X_j \qquad (i,\ j = 1,\ldots,n) \tag{A.2}$$

Deleting the final payments sector, the producing sectors can now be summarized as in Equation A.3 for all n producing sectors.

$$X_i - \sum_{j=1}^{n} a_{ij}X_j = \sum_{k=1}^{n} Y_{ik} \qquad (i = 1,\ldots,n) \tag{A.3}$$

The system defined by Equation A.3 can be expressed equivalently in matrix form as in A.4 or A.5.

$$\begin{pmatrix} (1 - a_{11}) & - a_{12} & \cdots & - a_{1n} \\ - a_{21} & (1 - a_{22}) & \cdots & - a_{2n} \\ \vdots & \vdots & & \\ -a_{n1} & - a_{n2} & \cdots & (1 - a_{nn}) \end{pmatrix} \begin{pmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \end{pmatrix} = \begin{pmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_n \end{pmatrix} \tag{A.4}$$

or

$$(I - A)\ X = Y \tag{A.5}$$

where A is a matrix of technical coefficients, I is an identity matrix of the same dimension as A, X is a n x 1 column vector of outputs, and Y is a n x 1 column vector of final demands. To solve this system for the X vector, the (I - A) matrix is inverted to form an interdependency table (such as Table 31). To do this, we define a new matrix R, where $R = (I - A)^{-1}$, which when expanded appears as in A.6;

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots\cdots\cdots & r_{1n} \\ r_{21} & r_{22} & \cdots\cdots\cdots & r_{2n} \\ \vdots & \vdots & & \vdots \\ r_{n1} & r_{n2} & \cdots\cdots\cdots & r_{nn} \end{bmatrix} \tag{A.6}$$

where r_{ij} is the amount of output of sector i required to deliver one unit of output of sector j to final demand. To convert to output terms, we define a further relationship, Equation A.7;

$$s_{ij} = r_{ij}/r_{ii} \text{ for all i and j} \tag{A.7}$$

to form a new matrix S as in A.8

$$S = \begin{bmatrix} s_{11} & s_{12} & \cdots\cdots\cdots & s_{1n} \\ s_{21} & s_{22} & \cdots\cdots\cdots & s_{2n} \\ \vdots & \vdots & & \vdots \\ s_{n1} & s_{n2} & \cdots\cdots\cdots & s_{nn} \end{bmatrix} \tag{A.8}$$

where each s_{ij} represents the amount of output of sector i required to produce one unit of output of sector j. Matrix S corresponds to Table 32.

Since outcomes for each of the structural alternatives imply a different productive technology for each farm production region, it is necessary to recalculate income-generation factors for each of the alternatives. The factors were re-estimated using coefficients based on the particular mix of productive inputs resulting for each of the model alternatives. Using the results of the linear programming model, the direct requirements table of the basic input-output table is altered to reflect the mix of productive inputs applicable for each alternative. The basic input-output data is from Schluter (34). To accomplish this, we first assume the proportion of nonfarm inputs to total inputs (per dollar of total inputs) remains constant for all the alternatives. Then the mix of nonfarm inputs (fertilizer, machinery, and labor) is adjusted based on the proportion of each of them specified in the programming model. This altered direct-requirements table is then taken through the steps outlined above to estimate new income-generation factors for each model alternative under consideration. The income-generation factors estimated for the seven model alternatives are presented in Tables 33 through 39.

These income-generation factors are defined as the amount by which the total income in the U.S. economy will change because of a one dollar change in the value of output in each sector. Here, a sector represents a specific farm commodity

Table 33. Income generation factors for each of the ten farm production regions for Alternative A

Region	Wheat	Feed grains	Soybeans	Cotton
(Dollars of income generated per dollar of output)				
Northeast	1.40084	1.29306	1.42998	--
Corn Belt	1.32709	1.27622	1.06933	1.57638
Lake States	1.38026	1.36168	1.18379	--
Appalachian	1.35832	1.44246	1.23305	1.68357
Southeast	1.27554	1.45395	0.93880	1.59416
Delta States	0.82475	1.40229	0.99208	1.59576
Southern Plains	0.99651	1.39401	0.96348	1.68070
Northern Plains	1.21338	1.27173	1.17654	--
Mountain	1.20254	1.36146	1.30884	1.62195
Pacific	0.89540	1.36627	1.30884	1.62014

Table 34. Income generation factors for each of the ten farm production regions for Alternative B

Region	Wheat	Feed grains	Soybeans	Cotton
(Dollars of income generated per dollar of output)				
Northeast	1.40090	1.29446	1.42916	--
Corn Belt	1.32061	1.27795	1.06845	1.57645
Lake States	1.37704	1.36304	1.18154	--
Appalachian	1.36065	1.43993	1.23264	1.70303
Southeast	1.27583	1.44828	0.93951	1.61676
Delta States	0.83017	1.41127	0.99274	1.59441
Southern Plains	0.99867	1.39407	0.96460	2.16698
Northern Plains	1.21613	1.37458	1.17534	--
Mountain	1.20159	1.36469	1.30889	1.62202
Pacific	0.89543	1.36632	1.30889	1.62020

Table 35. Income generation factors for each of the ten farm production regions for Alternative C

Region	Wheat	Feed grains	Soybeans	Cotton
(Dollars of income generated per dollar of output)				
Northeast	1.39990	1.30142	1.43628	--
Corn Belt	1.32216	1.27478	1.06487	1.57425
Lake States	1.38118	1.36315	1.18363	--
Appalachian	1.35009	1.43104	1.22106	1.62808
Southeast	1.27708	1.44472	0.93515	1.61782
Delta States	0.82415	1.40984	0.98190	1.54946
Southern Plains	0.99692	1.38881	0.96755	1.68544
Northern Plains	1.21691	1.37864	1.17367	--
Mountain	1.20155	1.36550	1.38072	1.61145
Pacific	0.89524	1.35376	1.30872	1.61978

Table 36. Income generation factors for each of the ten farm production regions for Alternative D

Region	Wheat	Feed grains	Soybeans	Cotton
(Dollars of income generated per dollar of output)				
Northeast	1.39739	1.29498	1.43410	--
Corn Belt	1.31682	1.26730	1.06719	1.58623
Lake States	1.37535	1.36046	1.18471	--
Appalachian	1.33995	1.41023	1.21661	1.60541
Southeast	1.25440	1.42985	0.92703	1.53595
Delta States	0.81146	1.38926	0.97612	1.55832
Southern Plains	0.98537	1.37935	0.96588	1.69874
Northern Plains	1.21048	1.36549	1.16869	--
Mountain	1.19647	1.35808	1.30856	1.62647
Pacific	0.88663	1.35776	1.30856	1.61725

Table 37. Income generation factors for each of the ten farm production regions for Alternative E

Region	Wheat	Feed grains	Soybeans	Cotton
(Dollars of income generated per dollar of output)				
Northeast	1.34721	1.29635	1.43565	--
Corn Belt	1.32302	1.27043	1.06540	1.58804
Lake States	1.36963	1.36447	1.18494	--
Appalachian	1.33287	1.42977	1.21659	1.61227
Southeast	1.25393	1.43299	0.92807	1.86646
Delta States	0.81242	1.39122	0.97655	2.07885
Southern Plains	0.97923	1.38464	0.97241	1.72079
Northern Plains	1.20980	1.36174	1.16973	--
Mountain	1.19473	1.35278	1.30985	1.62725
Pacific	0.88704	1.48818	1.30985	1.61918

Table 38. Income generation factors for each of the ten farm production regions for Alternative F

Region	Wheat	Feed grains	Soybeans	Cotton
(Dollars of income generated per dollar of output)				
Northeast	1.39987	1.30020	1.43612	--
Corn Belt	1.32377	1.27584	1.06434	1.57422
Lake States	1.38155	1.36255	1.18543	--
Appalachian	1.34972	1.43129	1.21847	1.64819
Southeast	1.44835	1.27843	0.93674	1.58800
Delta States	0.82590	1.40804	0.98075	1.54941
Southern Plains	0.99509	1.38947	0.96654	1.68542
Northern Plains	1.21471	1.37347	1.17466	--
Mountain	1.20111	1.36475	1.30870	1.60336
Pacific	0.89632	1.36045	1.30870	1.61975

Table 39. Income generation factors for each of the ten farm production regions for Alternative G

Region	Wheat	Feed grains	Soybeans	Cotton
	(Dollars of income generated per dollar of output)			
Northeast	1.40025	1.30033	1.43559	--
Corn Belt	1.32256	1.27379	1.06617	1.57406
Lake States	1.38485	1.36381	1.18307	--
Appalachian	1.34982	1.42992	1.22116	1.61431
Southeast	1.27736	1.45001	0.93516	1.54901
Delta States	0.82559	1.39911	0.98176	1.54870
Southern Plains	1.00063	1.38770	0.96213	1.64016
Northern Plains	1.21642	1.37438	1.17441	--
Mountain	1.20304	1.36569	1.30859	1.60802
Pacific	0.89685	1.32910	1.30859	1.61958

produced in a specific farm production region. This change in income contains three components: (1) changes in the income of farmers, (2) changes in the level of activity in agri-business industries, and (3) variations in the quantity of consumer goods purchased by farmers and by workers in agri-business industries.

The income-generation factors presented in Tables 33 through 39 refer to income generated per dollar of output. In any region, however, the total amount of income generated by the production of the four commodities is a function of the acreage, yield, and price of those commodities. To indicate this total secondary effect, the income-generation factors are linked to the value of output estimated for each commodity in the programming model.

Because of the large changes in farm prices among the model alternatives, one dollar's worth of output does not reflect the same physical quantity of output for each situation. For example, the quantity of output needed to equal one dollar's worth of sales for Alternative B is much less than for Alternative A. The income effects of these price changes would be expected to affect farmers' expenditure patterns between production and consumption goods. However, this change in the mix of expenditures is not captured here because of lack of data relating to expenditure patterns. Therefore the expenditure patterns of farm operators does not vary among the seven model alternatives.

To provide a comparison among the model alternatives, the product of the income-generation factors and value of output for each alternative is converted to an index form. These indices of secondary-income generation are presented in Table 28 in the text. To calculate these indices, Alternative A is used as the base alternative. For each region, each secondary income generation value is divided by the respective value under Alternative A (and then multiplied by 100). Now the secondary index values for the other six alternatives are expressed as percentage changes from Alternative A. This means that a secondary income value of 250 for Alternative B has the following meaning: The amount of income generated by production of the crop commodities endogenous to the programming model for Alternative A is 2.5 times that under Alternative B. This does not imply that the total income of the nation would vary by a factor of 2.5--rather, only the income generated by the production of wheat, feed grains, soybeans, and cotton differs by this multiple.

Because we relate value of output to secondary-income generation, supply control programs, as in Alternative G, are estimated to have positive secondary income effects even though farm output would be reduced (compared to a situation without supply control programs). This reduction in farm output would probably not have positive effects on the small rural community whose main source of employment is processing farm output or supplying farm inputs. However, the additional farm income associated with a supply control program can generate economic activity in larger rural towns serving as trade centers for the farm community. The income indices developed here relate to this multi-county, trade center concept and should be viewed in this manner. However, it should be noted that supply control programs may have negative rather than positive effects for the small rural village which is more dependent on the quantity of farm output produced than the value of that output.

APPENDIX B: ESTIMATION OF NATIONAL CASH RECEIPTS AND PRODUCTION EXPENSES

The linear programming model used in this analysis does not include all sectors of the agricultural industry as endogenous commodities. Therefore procedures were needed to relate the output of this model to national income and expenses, since this is the form many people are interested in when analyzing the agricultural industry. This section describes the procedures used to estimate national cash receipts and production expenses.

Cash Receipts

The programming model provides direct estimates of farm production for wheat, feed grains, soybeans, and cotton lint in each of the alternative situations of the analysis. To calculate cash receipts for the model crops, the production estimates had to be adjusted for that portion of production which is not sold from farms. For each commodity, the 1968-70 average proportion of production sold from farms is multiplied times its estimated production to form an estimate of sales from farms. These average proportions are 0.933 for wheat, 0.569 for feed grains, 0.980 for soybeans and 1.0 for cotton lint (42). Estimated sales are then multiplied times the model supply price to determine cash receipts for the four model crops in each alternative.

The model production estimates include only the 150 rural areas in the model. Production from the nonincluded areas of the nation (the White Areas) is set at 1969 production levels (71). These 1969 production levels are converted to a sales basis using the same factors as given in preceding paragraph. The resulting sales estimates are multiplied times the supply price relevant for each alternative to give White Area cash receipts.

From the demand procedures described in Chapter III, estimates of domestic production and price are available for beef, pork, broilers, and sheep and lambs. These parameters are combined to form an estimate of cash receipts from these four livestock commodities.

To this point, we have obtained direct estimates of cash receipts for eight agricultural sectors; wheat, feed grains, soybeans, cotton lint, beef, pork, broilers, and sheep and lambs. Cash receipts for agricultural commodities other than these eight are held constant at their 1970-72 average of 20.456 billion dollars (42). This constant figure is added to the cash receipts estimated for the eight included commodities to form an estimate of cash receipts for the agricultural sector.

Production Expenses

The first step in estimating national production expenses for this analysis is to calculate total expenses for Alternative A. Total farm production expenses are defined as the sum of operating and fixed expenses. Operating expenses include expenditures for feed; livestock replacement; seed; fertilizer and lime; petroleum, fuel, and oil; other motor vehicle and machinery operation; building repairs; hired labor; and miscellaneous items. All of these expense categories except other motor vehicle and machinery operations are estimated using regression procedures (see Equations B.1-B.8). Fixed expenses are defined as the sum of depreciation on buildings and machinery, taxes on farm property, interest on farm mortgage debt, and net rent to nonfarm landlords. For all seven of the alternatives in this analysis, fixed expenses are set at their 1969-71 average of $12.876 million (50).

$$Y_{1,t} = \underset{(920.7)}{-5643.754} + \underset{(6.14)}{84.546}\,X_{m,t} + \underset{(10.75)}{40.091}X_{r,t} \qquad R^2 = 0.93 \tag{B.1}$$

$$Y_{2,t} = \underset{(262.25)}{-1151.265} + \underset{(7.35)}{17.282}X_{m,t} + \underset{(6.03)}{30.826}X_{c,t} \qquad R^2 = 0.95 \tag{B.2}$$

$$Y_{3,t} = \underset{(55.31)}{-84.622} + \underset{(0.157)}{0.906}Y_{3,t-1} + \underset{(1.62)}{2.511}\text{ Year} \qquad R^2 = 0.90 \tag{B.3}$$

$$Y_{4,t} = \underset{(254.67)}{-323.436} + \underset{(0.089)}{0.927}Y_{4,t-1} + \underset{(6.26)}{8.263}\text{ Year} \qquad R^2 = 0.99 \tag{B.4}$$

$$Y_{5,t} = \underset{(190.52)}{489.627} + \underset{(0.18)}{0.612}Y_{5,t-1} + \underset{(1.69)}{1.929}\ \text{Year} \qquad R^2 = 0.84 \tag{B.5}$$

$$Y_{6,t} = \underset{(248.59)}{770.641} + \underset{(0.17)}{0.490}Y_{6,t-1} - \underset{(2.04)}{6.539}\ \text{Year} \qquad R^2 = 0.96 \tag{B.6}$$

$$Y_{7,t} = \underset{(1643.65)}{1413.539} + \underset{(0.142)}{0.827}Y_{7,t-1} - \underset{(17.95)}{13.882}\ \text{Year} \qquad R^2 = 0.97 \tag{B.7}$$

$$Y_{8,t} = \underset{(445.49)}{-913.253} + \underset{(0.078)}{0.881}Y_{8,t-1} + \underset{(11.14)}{23.28}\ \text{Year} \qquad R^2 = 0.996 \tag{B.8}$$

where:

$X_{m,t}$ is the index of meat production in year t (1967 = 100). This is formed by summing the meat production of cattle and calves, hogs, and sheep;

$X_{c,t}$ is an index of crop production in year t (1967 = 100). This index is formed by summing crop production in terms of feed units of wheat, feed grains, and soybeans;

$Y_{R,t}$ is an index of the ratio of the crop production index, $X_{c,t}$ to the meat production index, $X_{m,t}$ (1967 = 100);

Year represents a time trend after 1948, Year = 49 in 1949, 50 in 1950,...72 in 1972;

$Y_{i,t}$ is the estimated expenditures for the i-th expense category in the t-th year (i = 1,2,3,4,5,6,7,8, for feed; livestock purchases; seed; fertilizer and lime; petroleum, fuel, and oil; building repairs;

hired labor; and miscellaneous items, respectively.) Each $Y_{i,t}$ is in 1967 constant dollars using price indices specific to each expenditure category (42, 50).

Since no significant trend was found for expenditures for other vehicle and machinery operations, this expenditure category is held constant at its average value during this period, \$2.151 billion. The actual and predicted values from 1950 to 1972 for total operating expenses (the sum of the nine categories above) are presented in Table 40 below, as well as the percentage error for each year.

After estimating values for Alternative A for each of the expenditure categories in 1980, these estimated values had to be adjusted to reflect changes between it and the other six alternatives. To do this the nine expenditure categories were divided into two subsectors. One subset contained variables which varied among the model alternatives; expenditures for feed and livestock purchases. The other seven categories, which contain only time and their own value lagged one period, form the other subset. To calculate expenditures for the other six alternatives for this second subset, the estimates of Alternative A were adjusted by the percentage change in the cost of producing wheat, feed grains, soybeans, and cotton as determined in the programming model between each alternative and Alternative A.

Table 40. Actual and predicted total operating expenses for 1950-72

	Actual[a]	Predicted[a]	Percentage error		Actual[a]	Predicted[a]	Percentage error
	(million dollars)				(million dollars)		
1950	18,514	18,328	1.0	1962	22,414	21,216	5.3
1951	18,996	18,272	3.8	1963	22,928	22,111	3.6
1952	18,597	19,006	-2.2	1964	22,448	22,316	.6
1953	18,013	18,677	-3.7	1965	22,750	23,219	-1.7
1954	18,239	18,555	-1.7	1966	23,562	23,436	.5
1955	18,685	19,026	-1.8	1967	24,106	24,729	-2.6
1956	19,218	19,512	-1.5	1968	24,394	25,047	-2.7
1957	19,499	19,728	-1.2	1969	25,160	25,392	- .9
1958	20,662	20,434	1.1	1970	25,709	25,290	1.6
1959	20,992	20,710	1.3	1971	27,054	27,416	-1.3
1960	21,182	21,444	-1.2	1972	28,381	27,536	3.0
1961	21,507	21,445	1.7				

[a]All dollar values are in 1967 constant dollars. The basic source for the actual data is (42, 50).

The first subset contains explanatory variables whose values vary as the quantity of livestock demand and the production of grain varies in the analysis. Three levels for these two variables are used. One level of livestock demand and grain production is used for Alternatives B, C, D, and E. A second level is used for Alternatives A and F. And a third level is applied in Alternative G. These separate quantities were inserted directly in Equations B.1 and B.2 to estimate expenditures for these categories in Alternatives A, B, and G. Alternative A was assumed to serve as a base for Alternative F. Therefore the percentage change in the programming model cost of production between these two alternatives was used as an adjustment factor to calculate expenditures for Alternative F. Similarly, Alternative B served as a base for each of Alternatives C, D, and E. The percentage change between Alternative B and each of the other three situations was used to calculate expenditures for feed and for livestock purchases for Alternatives C, D, and E.

Indices specific to each of the expenditure categories were then used to convert the estimates from a 1967 dollar to a 1972 dollar base. For each of the model alternatives this estimate of total operating expense was then summed with 1969-71 average fixed expenses to form the estimate of total production expenses given in Table 23.

APPENDIX C: ESTIMATION OF AVERAGE FARM SIZE IN 1980

Average size of farm and number of commercial farms are two variables that are very important both to the farming industry itself and the rural community serving it. Therefore, differences between the model alternatives in the magnitude of these variables were factors which this analysis strived to capture.

Data on the number of farms and the acreage in those farms for each of the five classes of commercial farms defined by the Census Bureau is available for the years 1959, 1964, and 1969 (69,70,71). This data was first summed on a state basis to conform with the three farm structures basic to this analysis. Then for both farm numbers and acreage, the per year rate of change between 1959 and 1964 and between 1964 and 1969 was summed and averaged to give a per year rate of change. The resulting rates of change were continued from the 1969 value for each of these variables to calculate a 1980 estimate of farm numbers and acreage by state for each of the small-, medium-, and large-farm structures. To estimate average farm size for these three farm structures, the projected acreage was divided by the projected number of farms. For the typical farm structure, the projected number of farms and acreage for the three separate categories was summed and then divided to estimate average farm size for this category.

Now it still remains to relate average farm size for each of the farm structures to an average farm size for the seven model alternatives. From the programming model, we can obtain estimates at the state level of the acreage of wheat, feed grains, soybeans, and cotton lint for each of the model alternatives. From the 1969 Census of Agriculture (71), data for that year was available which related the total acreage in farms to the acreage of the four above-mentioned commodities for each state. By combining this ratio with the output of the programming model, it was then possible to estimate the number of farms and their average size for each state in each alternative. These state estimates were then averaged to form a national average farm size, given in Table 41 below.

Table 41. Estimated national average size of farm for each of the alternatives

	1971 actual[a]	Model alternatives						
		A	B	C	D	E	F	G
Average farm size (acres)	389	619	626	532	1,110	1,093	525	516

[a]Source: (68).

APPENDIX D: ESTIMATED EXPENDITURES BY TYPE OF INPUT

Table 42. Value of machinery and equipment expenses required to produce the endogenous crops for each of the model alternatives on a national and a farm production region basis

	A	B	C	D	E	F	G
United States	8,936,325	9,884,182	9,875,544	7,930,328	7,611,059	8,942,488	9,129,533
Northeast	253,187	253,584	255,570	181,961	183,795	255,291	241,830
Corn Belt	2,853,513	2,900,326	2,868,261	2,369,778	2,363,645	2,847,036	2,876,281
Lake States	844,684	897,309	843,285	667,295	664,836	797,287	827,852
Appalachian	406,881	540,609	538,961	431,428	417,447	344,907	443,727
Southeast	399,682	589,218	625,245	461,156	389,874	456,590	467,575
Delta States	559,567	617,862	714,491	535,813	428,757	658,648	714,580
Southern Plains	1,161,154	1,204,275	1,179,724	908,431	879,794	1,166,689	1,174,242
Northern Plains	1,692,036	2,079,851	2,020,439	1,672,759	1,570,109	1,658,220	1,755,556
Mountain	471,543	507,070	544,390	427,204	412,885	474,567	409,637
Pacific	294,078	294,078	285,178	274,503	299,917	283,253	218,253

Table 43. Value of labor required to produce the endogenous crops for each of the model alternatives on a national and a farm production region basis

	A	B	C	D	E	F	G
United States	1,837,351	2,009,451	1,929,775	1,689,238	1,666,113	1,781,320	1,731,487
Northeast	41,430	41,181	45,466	40,817	41,599	45,726	42,175
Corn Belt	618,561	622,902	594,971	557,272	560,180	597,542	596,705
Lake States	195,695	207,280	206,305	187,535	184,748	196,844	205,649
Appalachian	60,074	89,799	53,730	47,740	53,660	38,340	45,734
Southeast	48,643	82,517	87,152	45,806	38,609	55,658	44,973
Delta States	98,252	107,161	83,469	71,994	53,391	75,161	83,626
Southern Plains	283,504	300,422	289,642	255,536	262,096	284,544	256,517
Northern Plains	288,531	348,472	359,865	291,374	270,775	295,696	304,783
Mountain	103,655	110,711	113,162	99,664	98,283	96,929	87,003
Pacific	99,006	99,006	96,013	91,500	102,772	94,880	64,322

Table 44. Value of fertilizer required to produce the endogenous crops for each of the model alternatives on a national and a farm production region basis

	A	B	C	D	E	F	G
United States	3,077,742	3,239,219	3,242,008	3,258,260	3,248,324	3,068,007	3,028,636
Northeast	84,526	81,118	81,118	81,118	82,621	84,526	78,826
Corn Belt	1,350,105	1,277,843	1,291,191	1,308,613	1,320,627	1,332,296	1,351,785
Lake States	267,111	248,258	254,260	256,373	248,812	270,074	258,565
Appalachian	115,516	165,575	163,987	165,169	145,820	110,881	114,763
Southeast	93,573	164,086	167,741	170,227	170,134	106,054	111,608
Delta States	89,972	100,879	102,863	108,484	111,293	93,435	83,931
Southern Plains	249,220	256,865	258,235	258,363	259,497	252,576	257,290
Northern Plains	575,425	681,603	659,309	647,418	633,530	569,028	574,220
Mountain	137,807	148,505	148,228	148,008	147,785	134,650	117,402
Pacific	114,487	114,487	115,076	114,487	128,205	114,487	80,246

Table 45. Value of seed required to produce the endogenous crops for each of the model alternatives on a national and a farm production region basis

	A	B	C	D	E	F	G
United States	359,589	373,407	375,277	378,015	377,852	361,653	360,332
Northeast	11,982	11,392	11,392	11,392	11,822	11,982	10,415
Corn Belt	185,247	174,775	176,358	178,747	181,848	184,815	184,510
Lake States	40,714	43,434	43,418	42,192	41,002	41,110	43,201
Appalachian	10,218	12,692	12,394	12,308	9,634	9,529	10,121
Southeast	9,084	14,356	16,389	16,733	17,329	11,113	11,883
Delta States	9,636	11,543	12,438	13,578	15,595	10,544	9,011
Southern Plains	24,859	26,434	26,335	26,222	25,472	25,845	24,493
Northern Plains	57,936	68,542	66,194	66,542	65,536	56,978	58,100
Mountain	7,358	7,684	7,719	7,746	7,250	7,182	6,648
Pacific	2,555	2,555	2,640	2,555	2,364	2,555	1,950

Table 46. Value of miscellaneous inputs required to produce the endogenous crops for each of the model alternatives on a national and a farm production region basis

	A	B	C	D	E	F	G
United States	983,690	1,040,794	1,046,972	1,038,840	974,373	984,986	1,009,152
Northeast	17,877	17,584	17,584	17,584	18,083	17,877	16,320
Corn Belt	289,865	276,960	279,870	283,685	283,286	489,024	293,594
Lake States	62,954	66,630	66,366	64,740	62,033	63,552	67,568
Appalachian	41,078	55,556	50,487	54,956	59,359	35,944	43,820
Southeast	60,324	85,437	94,354	81,592	56,062	71,023	66,204
Delta States	84,259	90,038	88,254	88,670	41,609	84,891	103,441
Southern Plains	187,937	193,145	197,779	197,778	185,456	190,343	236,560
Northern Plains	83,929	98,331	94,185	92,110	89,915	83,068	83,275
Mountains	65,400	67,046	67,387	67,658	71,008	59,197	48,024
Pacific	90,067	90,067	90,796	90,067	107,562	90,067	50,346